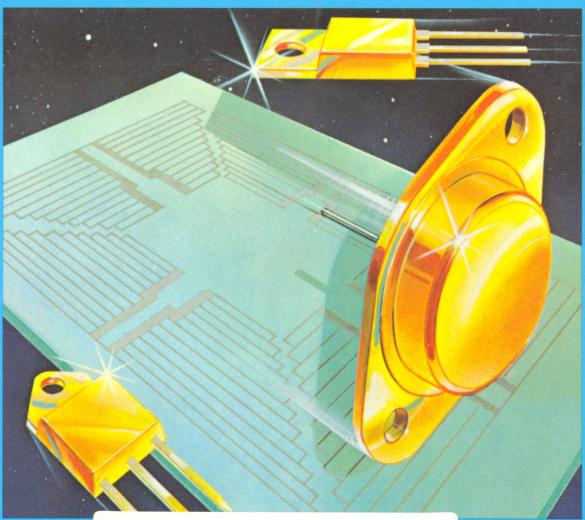


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# BIPOLAR POWER TRANSISTOR DATA

Index and Cross Reference

Selector Guide 2

**Data Sheets** 

3

5

Mechanical Data

**Application Notes** 

quantum electronics

Box 391262

Bramley
2018

# Index and Cross Reference

Selector Guida

Data Sheets

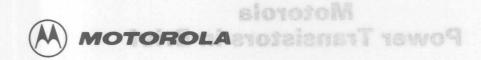
**Mechanical Data** 

Application Notes

quantum electronics

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Wide Range of Transistor Specifications

Bipolar transistors, NPNs and PNPs, single and multiple (Darlington) transistor structures, metal and plastic packages, Motorola's inventory of more than 1100 stendard (off-the-shelf) power transistors covers the widest range of specifications for virtually every potential applications requirement.

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Consisting of two transistors, up to two resistors, and (up to) two diodes on a single chip, Derlington transistors achieve gain figures up to 20,000 in a single package. Rapid line expansion, and the resulting widespread implementation make Motorola Dartingtons highly cost-effective in a fast growing number of applications.

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# Motorola Power Transistors in Brief



#### Wide Range of Transistor Specifications

Bipolar transistors, NPNs and PNPs, single and multiple (Darlington) transistor structures, metal and plastic packages, Motorola's inventory of more than 1100 standard (off-the-shelf) power transistors covers the widest range of specifications for virtually every potential applications requirement.

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Consisting of two transistors, up to two resistors, and (up to) two diodes on a single chip, Darlington transistors achieve gain figures up to 20,000 in a single package. Rapid line expansion, and the resulting widespread implementation make Motorola Darlingtons highly cost-effective in a fast growing number of applications.

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# INDEX-CROSS REFERENCE

1 10	Dota Shoa Page	Selector Guide Page	Motorola Similar Replacement	Materials Direct Replacement		Data Sheet Page	Selector Golde Page	Motorcia Similar Replacement	Motorola Direct Replacement	industry Part Number
the second secon	3-145 3-26 3-26 3-26 3-26 3-26 3-26 3-26	2.4 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0			Inde	3-140 3-140 3-140 3-140 3-160 3-56 3-56 3-56 3-56	nd C	cross	Refe	2N1487 2N1 689 2N C 202 2N 6002 2N 6002
	e tab	8.5 8.5 8.5 8.5 8.5 8.5 8.5 8.5	the subse	WITH THE TOWN TO T	ges contai	ns an	23 23 28 28 28 24 24 24 24 24		2N3054 2N3054A 2N3055 2N3055A	ZNSYZE ZNSOSE ZNSOSE ZNSOSE ZNSOSEH ZNSOSEN ZNSOSESE ZNSOSESE ZNSOSESE ZNSOSESE
currer indust The acteri	ntly try. e colu	mani umn h	ufactured eaded "Sii might re	and av	ailable to aunits with uitable represented	char-	24 22 22 23 23 23 23 23 24 24 25 25 26 27 28 28 28 28 28 28 28 28 28 28 28 28 28	2NG249 2NG542 2NG542 2NG749 2NG749 2NG749 2NG749 2NG749 2NG749		2M3078 2N3079 2N3079 2N3171 2N3172 2N3173 2N3174 2N3183 2N3183
conte should device that c	mpla d be e be	ated, e care ing re	the Moto	orola dev npared w determin	ice data ith one fo e any varia	sheet or the	22 23 23 23 22 22 23 23 23 23 23 23 23 2	2N6228 2N3739 2N3739 2N3279 2N3279 2N3720 2N5272 2N5277 2N5532		2N3186 2N3185 2N3186 2N318 2N328 2N3203 2N3203 2N3226 2N3226
				2N3790 2N3791 2N3791JTX 2N3791JTXV 2N3792 2N3792 2N3792JAN 2N3792JTXV 2N3792JTXV	2N3790 2N3791JAM 2N3791JTX 2N3791JTXV 2N3792JAM 2N3792JAM 2N3792JTXV 2N3792JTXV 2N3792JTXV	3-133 3-6 3-122 3-98 3-143 3-143 3-102 3-102	22 42 52 82 83 84 24 24 72 72 72	2N5760 2N3055 2N5632 2N5632 2N5682 2N5582 2N539 2N539 2N539 2N539		2MS206 2NC236 3NE226 2NC237 2NC237 2NE238 2NE328 2NE320 2NE320 2NE320 2NE320 2NE320
		2:8 2:27 2:27 2:27 2:27 2:27 2:27 2:27 2		2N3867 ZN3867 JAN ZN3867 JTX ZN3867SJAN ZN3867SJAN ZN3867 SJTXV ZN3860 ZN3860	ZN3865 ZN3865 ZN3867 ZN3867JAN ZN3967JTX ZN3967JTX ZN3967SJAN ZN3967SJTX ZN3967SJTX ZN3967SJTX	3-102 3-15 3-16 3-18 3-18 3-16 3-20 3-20 3-20	27 28 28 29 29 28 28 28 28 28			RHSART RNSART RNSARG RNSARG RNSARG RNSARG RNSARG RNSARG RNSARG RNSARG RNSARG

\* To be introduced. Contact fectory for Data Sheet.

# **INDEX-CROSS REFERENCE**

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page		Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2N1487 2N1488 2N1489 2N1490 2N1702 2N3016 2N3021 2N3022 2N3023 2N3024	Refer	2N5877 2N5878 2N5877 2N5877 2N5878 2N5877 2N5337 2N3789 2N3789 2N3789 2N3789 2N3789	2-3 2-3 2-3 2-3 2-3 2-7 2-3 2-3 2-3 2-3	3-140 3-140 3-140 3-140 3-140 3-102 3-56 3-56 3-56 3-56	7 8 20	2N3667 2N3713 2N3714 2N3715 2N3715 2N3715JAN 2N3715JTX 2N3715JTXV 2N3716 2N3716 2N3716JAN 2N3716JTX	2N3713 2N3714 2N3715 2N3715JAN 2N3715JTX 2N3715JTXV 2N3716 2N3716JAN 2N3716JTX	2N5881	2-4 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-143 3-26 3-26 3-26 3-26 3-26 3-26 3-26 3-2
2N3025 2N3026 2N3054 2N3054A 2N3055 2N3055A 2N3055A 2N3055H 2N3055JAN 2N3055SD 2N3055UB	2N3054 2N3054A 2N3055 2N3055A	2N3791 2N3791 2N3055A 2N5302JAN 2N3055A 2N3055A	2-3 2-8 2-8 2-4 2-4 2-4 2-4 2-4 2-4	3-56 3-56 3-2 3-2 3-6 3-6 3-6 3-6 3-6	nie	2N3716JTXV 2N3719 2N3720 2N3738 2N3739 2N3739JAN 2N3739JTX 2N3739JTXV 2N3740	2N3716JTXV 2N3719 2N3720 2N3738 2N3739 2N3739JAN 2N3739JTX 2N39JTXV 2N3740	sedua orti	2-3 2-27 — 2-8 2-8 2-8 2-8 2-8	3-26 3-32 3-32 3-37 3-37 3-37 3-37 3-41 3-41
2N3076 2N3079 2N3080 2N3171 2N3172 2N3173 2N3174 2N3183 2N3184 2N3185		2N6249 2N5838 2N6542 2N3789 2N3789 2N3790 2N6226 2N3789 2N3789 2N3789	2-4 2-2 2-2 2-3 2-3 2-3 2-2 2-3 2-3 2-3 2-3	3-201 3-137 3-253 3-56 3-56 3-56 3-133 3-56 3-56 3-56	oti oti oti oti oti	2N3740JAN 2N3740JTX 2N3740JTXV 2N37411 2N37411A 2N3741JTX 2N3741JTXV 2N3766JAN 2N3766JAN 2N3766JTX	2N3740JAN 2N3740JTX 2N3740JTXV 2N3741 2N3741A 2N3741JTX 2N3741JTXV 2N3766 2N3766JAN 2N3766JTX	ndex of 8 ifactured paded "Sit might rep is where	2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-41 3-41 3-41 3-41 3-41 3-41 3-44 3-44
2N3186 2N3195 2N3196 2N3197 2N3198 2N3202 2N3203 2N3204 2N3232 2N3233		2N6226 2N3789 2N3789 2N3790 2N6226 2N3719 2N3720 2N6303 2N5877 2N5632	2-2 2-3 2-3 2-3 2-2 2-3 2-3 2-27 2-3 2-3	3-133 3-56 3-56 3-56 3-133 3-32 3-32 3-32 3-154 3-122	e ncil	2N3766JTXV 2N3767 2N3767JAN 2N3767JTX 2N3767JTX 2N37767JTXV 2N3771 2N3772 2N3773 2N3788 2N3789	2N3766JTXV 2N3767 2N3767JAN 2N3767JTX 2N3767JTX 2N3771 2N3772 2N3773 2N3789	the Moto fully con placed to t circuit p 2N6542	2-8 2-8 2-8 2-8 2-8 2-5 2-5 2-4 2-2 2-3	3-44 3-44 3-44 3-44 3-48 3-48 3-52 3-253 3-56
2N3234 2N3235 2N3236 2N3237 2N3238 2N3239 2N3240 2N3418 2N3419 2N3420		2N5760 2N3055 2N5632 2N5302 2N5882 2N5882 2N5882 2N5882 2N5336 2N5336	2-2 2-4 2-3 2-8 2-8 2-4 2-4 2-7 2-7 2-7	3-133 3-6 3-122 3-98 3-143 3-143 3-102 3-102 3-102		2N3790 2N3791 2N3791JAN 2N3791JTX 2N3791JTXV 2N3792 2N3792JAN 2N3792JTX 2N3792JTX 2N3792JTXV 2N3863	2N3790 2N3791 2N3791JAN 2N3791JTX 2N3791JTXV 2N3792 2N3792JAN 2N3792JTX 2N3792JTX	2N3715	2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-56 3-56 3-56 3-56 3-56 3-56 3-56 3-56
2N3421 2N3441 2N3442 2N3445 2N3446 2N3446 2N3448 2N3583 2N3584 2N3585	2N3441 2N3442 2N3445 2N3446 2N3447 2N3448 2N3583 2N3584 2N3585	2N5336	2-7 2-8 2-3 2-3 2-3 2-3 2-3 2-8 2-8 2-8	3-102 3-13 3-15 3-18 3-18 3-18 3-20 3-20 3-20		2N3864 2N3865 2N3867 2N3867JAN 2N3867JTX 2N3867JTXV 2N3867SJAN 2N3867SJTX 2N3867SJTXV 2N3867SJTXV 2N3868	2N3867 2N3867JAN 2N3867JTX 2N3867JTXV 2N3867SJAN 2N3867SJTX 2N3867SJTXV 2N3867SJTXV 2N3868	2N5632 2N5634	2-3 2-3 2-27 2-27 2-27 2-27 2-27 2-27 2-	3-122 3-122 3-32 3-32 3-32 3-32 3-32 3-3

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beauting) 30/43/33/34 220/30/44

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2N3868JAN 2N3868JTX 2N3868JTX 2N3868SJAN 2N3868SJTX 2N3868SJTX 2N3878 2N3879 2N3879 2N3996	2N3868JAN 2N3868JTX 2N3868JTXV 2N3868SJAN 2N3868SJTX 2N3868SJTXV	2N5428 2N5430 2N5347		3-32 3-32 3-32 3-32 3-32 3-114 3-114 3-60 3-110	2N4910 2N4911 2N4912 2N4913 2N4914 2N4915 2N4918 2N4919 2N4920 2N4921	2N4912 2N4918 2N4919 2N4920 2N4921	2N3054* 2N3054* 2N5758* 2N5758* 2N5758*	2-8 2-8 2-2 2-2 2-2 2-9 2-9 2-9 2-9	3-2 3-75 3-133 3-133 3-133 3-78 3-78 3-78 3-82
2N3997 2N3998 2N3999 2N4000 2N4001 2N4002 2N4003 2N4070 2N4071 2N4111	7685 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	2N5347 2N5347 2N5347 2N5347 2N5339 2N6274 2N6274 2N6306 2N6306 2N37815	2-28 2-28 2-28 2-28 2-7 2-6 2-6 2-3 2-3 2-3	3-110 3-110 3-110 3-110 3-102 3-205 3-205 3-205 3-218 3-26	2N4922 2N4923 2N4998 2N4999 2N5000 2N5000 2N5001 2N5002 2N5003 2N5004 2N5005	2N4922 2N4923	2N5347 2N6187 2N5347 2N5347 2N5347 2N6187 2N5347 2N5347 2N6187	2-9 2-9 2-28 2-28 2-28 2-28 2-28 2-28 2-	3-82 3-82 3-110 3-189 3-110 3-189 3-110 3-189
2N4113 2N4115 2N4116 2N4231A 2N4232A 2N4233A 2N4240 2N4296 2N4297 2N4298	2N4231A 2N4232A 2N4233A 2N4240	2N3716 2N5347 2N5347 2N5347 2N3738 2N3738 2N6235	2-3 2-28 2-28 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2	3-26 3-110 3-110 3-64 3-64 3-64 3-20 3-37 3-37 3-198	2N5034 2N5035 2N5036 2N5037 2N5038 2N5038JAN 2N5038JTX 2N5038JTXV 2N5038JTXV 2N5039	2N5038 2N5038JAN 2N5038JTX 2N5038JTXV 2N5039 2N5039JAN	2N3055 2N3055 2N3055 2N3055 2N3055	2-4 2-4 2-4 2-5 2-5 2-5 2-5 2-5 2-5	3-6 3-6 3-6 3-86 3-86 3-86 3-86 3-86 3-8
2N4299 2N4300 2N4301 2N4305 2N4307 2N4307 2N4309 2N4311 2N4314 2N4347 2N4348	2N4347	2N6235 2N5337 2N5337 2N5337 2N5337 2N5337 2N5339 2N5337 2N3868 2N5630*	2-8 2-7 2-7 2-7 2-7 2-7 2-7 2-27 2-27 2-	3-198 3-102 3-102 3-102 3-102 3-102 3-102 3-32 3-15 3-118	2N5039JTX 2N5039JTXV 2N5050 2N5051 2N5051 2N5067 2N5068 2N5069 2N5083 2N5084	2N5039JTX 2N5039JTXV 2N5050 2N5051 2N5052	2N5758* 2N5758* 2N5758* 2N5758* 2N5347 2N5347	2-5 2-5 2-8 2-8 2-8 2-2 2-2 2-2 2-2 2-28 2-28	3-86 3-86 3-88 3-88 3-133 3-133 3-133 3-110 3-110
2N4387 2N4388 2N4398 2N4399 2N4399JAN 2N4399JTX 2N4399JTXV 2N4399JTXV 2N4898 2N4898 2N4899	2N4398 2N4399 2N4399JAN 2N4399JTX 2N4399JTXV 2N4398 2N4899	2N4898 2N4898 2N5337	2-8 2-8 2-5 2-5 2-5 2-5 2-5 2-7 2-8 2-8	3-72 3-72 3-68 3-68 3-68 3-68 3-102 3-72 3-72	2N5085 2N5147 2N5148 2N5149 2N5150 2N5151 2N5152 2N5153 2N5154 2N5157	\$181 5792 2191 2197 1157 1157 2189 2189	2N5347 2N6191 2N5337 2N6191 2N5337 2N6191 2N5337 2N6191 2N5337 2N6545	2-28 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7	3-110 3-192 3-102 3-192 3-102 3-192 3-102 3-192 3-259
2N4900 2N4901 2N4902 2N4903 2N4904 2N4905 2N4906 2N4906 2N4907 2N4908 2N4909	2N4900	2N6226* 2N6226* 2N6226* 2N6226* 2N6226* 2N6226* 2N3791 2N3791 2N3792	2-8 2-2 2-2 2-2 2-2 2-2 2-2 2-3 2-3 2-3	3-72 3-133 3-133 3-133 3-133 3-133 3-133 3-56 3-56 3-56	2N5190 2N5191 2N5192 2N5192 2N5193 2N5194 2N5195 2N5202 2N5239 2N5240 2N5241	2N5190 2N5191 2N5192 2N5193 2N5194 2N5195	2N5428 2N6306 2N6544 2N3902*	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-28 2-3 2-3 2-3 2-2	3-90 3-90 3-94 3-94 3-94 3-114 3-218 3-259 3-60

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\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (bounting) 30/43/83/39 880/80 X30/41

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Shee Page
2N5264 2N5284 2N5285 2N5286 2N5287 2N5297 2N5293 2N5294 2N5295 2N5295 2N5296 2N5297	*8664 *6676 *6676 *6776	2N6249 2N5347 2N5347 2N6189 2N6189 2N6123 2N6123 2N6121 2N6121 2N6121	2-7 2-7 2-18 2-18 2-18	3-201 3-110 3-110 3-189 3-189 3-185 3-185 3-185 3-185 3-185 3-185	2N5492 2N5493 2N5494 2N5495 2N5496 2N5497 2N5508 2N5539 2N5559	5428 2 5430 2 5347 2	2N6292 2N6292 2N6290 2N6290 2N6292 2N6292 2N5428 2N6379 2N5633 2N5685	2-19 2-19 2-19 2-19 2-19 2-19 2-8 2-6 2-3 2-6	3-182 3-182 3-182 3-182 3-182 3-114 3-229 3-122 3-129
2N5298 2N5301 2N5302 2N5302JAN 2N5302JTX 2N5302JTXV 2N5303JAN 2N5303JAN 2N5303JTX 2N5303JTX	2N5301 2N5302 2N5302JAN 2N5302JTX 2N5302JTXV 2N5303 2N5303JAN 2N5303JTX 2N5303JTX	2N6122		3-185 3-98 3-98 3-98 3-98 3-98 3-98 3-98 3-98	2N5578 2N5598 2N5600 2N5502 2N5604 2N5606 2N5610 2N5612 2N5614 2N5616	\$347 22 \$347 22 \$347 22 \$347 22 \$529 23 \$274 22 \$3276 22 \$306 22 \$3915 22	2N5685 2N5428 2N5428 2N5428 2N5430 2N5428 2N5428 2N5428 2N5428 2N5430 2N3448 2N3448	2-6 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-3 2-3	3-129 3-114 3-114 3-114 3-114 3-114 3-118 3-18
2N5326 2N5333 2N5334 2N5335 2N5336 2N5337 2N5338 2N5339 2N5344 2N5345	2N5336 2N5337 2N5338 2N5339 2N5344 2N5345	2N5347 2N6303 2N5337 2N5337 2N5337	2-28 2-27 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-8 2-8	3-110 3-32 3-102 3-102 3-102 3-102 3-102 3-102 3-106 3-106	2N5618 2N5629 2N5630 2N5631 2N5632 2N5633 2N5634 2N5651 2N5655 2N5656	2N5629 2N5630 2N5631 2N5632 2N5633 2N5634 2N5655 2N5656	2N3448  ALEST ASSESS ASSESS ASSESS 2N6235	2-3 2-4 2-4 2-4 2-3 2-3 2-3 2-8 2-9 2-9	3-18 3-11 3-11 3-12 3-12 3-12 3-12 3-12
2N5346 2N5347 2N5348 2N5348 2N5384 2N5384 2N5385 2N5386 2N5387 2N5388 2N5389	2N5346 2N5347 2N5348 2N5349	2N6187 2N6187 2N5038 2N6546 2N6546 2N6546	2-28 - 2-28 2-28 2-28 2-28 2-5 2-4 2-4 2-4	3-110 3-110 3-110 3-110 3-110 3-189 3-189 3-86 3-263 3-263 3-263	2N5657 2N5660 2N5664 2N5665 2N5671 2N5672 2N5678 2N5683 2N5683 2N5683JAN 2N5683JTX	2N5657 2N5683 2N5683JAN 2N5683JTX	2N6233 2N6233 2N6235 2N6338 2N6339 2N6378	2-9 2-8 2-8 2-8 2-6 2-6 2-6 2-6 2-6 2-6	3-12 3-19 3-19 3-19 3-22 3-22 3-22 3-12 3-12
2N5404 2N5405 2N5406 2N5407 2N5408 2N5409 2N5410 2N5411 2N5427 2N5428	2N5427 2N5428	2N6191 2N6192 2N6191 2N6193 2N6187 2N6189 2N6187 2N6189	2-7 2-7 2-7 2-7 2-28 2-7 2-7 2-7 2-8 2-8	3-192 3-192 3-192 3-192 3-189 3-189 3-189 3-114 3-114	2N5683JTXV 2N5684 2N5684JAN 2N5684JTX 2N5684JTX 2N5685JAN 2N5685JAN 2N5685JTX 2N5685JTX 2N5686	2N5683JTXV 2N5684 2N5684JAN 2N5684JTX 2N5684JTX 2N5685 2N5685JAN 2N5685JAN 2N5685JTX 2N5685JTXV 2N5686	1399 1399 1399JTX 1399JTXV 1399JTXV	2-6 2-6 2-6	3-129 3-129 3-129 3-129 3-129 3-129 3-129 3-129
2N5429 2N5430 2N5466 2N5467 2N5477 2N5477 2N5478 2N5479 2N5480 2N5490 2N5491	2N5429 2N5430 8KA 8008 4-38	2N6545 2N6545 2N5347 2N5347 2N5349 2N5349 2N6290 2N6290	2-8 2-3 2-3	3-114 3-114 3-259 3-259 3-110 3-110 3-110 3-110 3-182 3-182	2N5686JAN 2N5686JTX 2N5686JTXV 2N5729 2N5730 2N5733 2N5734 2N5737 2N5738 2N5738	2N5686JAN 2N5686JTX 2N5686JTXV	2N5337 2N5347 2N6274 2N6338 2N5878 2N6229	2-6 2-6 2-6 2-7 2-28 2-6 — 2-3 2-3	3-129 3-129 3-102 3-110 3-209 3-229 3-140 3-121 3-140

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

\*Consult fis lony if a direct replacement is recessary.

\*\* To be Intro-Lond. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beunitro3) 30/13/43/34 220/10/14

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Shee Page
2N5740 2N5741 2N5742 2N5743 2N5743 2N5745 2N5745 2N5745JTX 2N5745JTXV 2N5745JTXV 2N5758	2N5745 2N5745JAN 2N5745JTX 2N5745JTXV 2N5758	2N6229 2N5883 2N6029 2N5883 MJ4502	2-3 2-4 2-4 2-6 2-5 2-5 2-5 2-5 2-5 2-5	3-122 3-147 3-118 3-147 3-758 3-68 3-68 3-68 3-68 3-133	2N5983 2N5984 2N5985 2N5986 2N5987 2N5988 2N5989 2N5990 2N5991 2N6021	2N5986 2N5987 2N5988 2N5989 2N5990 2N5991	6108	2-11 2-11 2-11 2-11 2-11 2-11 2-11 2-11	3-113 3-157 3-157 3-157 3-157 3-157 3-157 3-188
2N5759 2N5760 2N5804 2N5805 2N5838 2N5839 2N5840 2N5867 2N5868 2N5869	2N5759 2N5760 2N5838 2N5839 2N5840	2N6306 2N6542 2N3789* 2N3790* 2N3713*	2-2 2-2 2-3 2-2 2-2 2-2 2-2 2-3 2-3 2-3	3-133 3-133 3-218 3-253 3-137 3-137 3-137 3-56 3-56 3-56	2N6022 2N6023 2N6024 2N6025 2N6026 2N6029 2N6030 2N6031 2N6031 2N6032 2N6033	2N6029 2N6030 2N6031	2N6126 2N6124 2N6124 2N6125 2N6125 2N6125 2N6275 2N6277	2-18 2-18 2-18 2-18 2-18 2-4 2-4 2-4 2-6 2-29	3-185 3-185 3-185 3-185 3-185 3-118 3-118 3-205 3-205
2N5870 2N5871 2N5872 2N5873 2N5874 2N5875 2N5876 2N5876 2N5877 2N5878	2N5875 2N5876 2N5877 2N5878 2N5879	2N3714* 2N3789* 2N3790* 2N3713* 2N3714*	2-3 2-3 2-3 2-3 2-3	3-26 3-56 3-56 3-26 3-26 3-140 3-140 3-140 3-140 3-143	2N6034 2N6035 2N6036 2N6037 2N6038 2N6039 2N6040 2N6041 2N6042 2N6043	2N6034 2N6035 2N6036 2N6037 2N6038 2N6039 2N6040 2N6041 2N6042 2N6043	6132 6132 6134 6134 Mil Mil Mil Mil Mil Mil Mil Mil Mil Mil	2-10 2-10 2-10 2-10 2-10 2-10 2-19 2-19 2-19 2-19	3-16 3-16 3-16 3-16 3-16 3-16 3-16 3-16
2N5880 2N5881 2N5882 2N5883 2N5884 2N5885 2N5886 2N5929 2N5930 2N5931	2N5880 2N5881 2N5882 2N5883 2N5884 2N5885 2N5886	2N6338 2N6338 2N6341	2-4 2-4 2-4 2-5 2-5 2-5 — — 2-5	3-143 3-143 3-143 3-147 3-147 3-147 3-226 3-226 3-226	2N6044 2N6045 2N6049 2N6050 2N6051 2N6051JAN 2N6051JTX 2N6051JTXV 2N6052 2N6052JAN	2N6044 2N6045 2N6049 2N6050 2N6051 2N6051JAN 2N6051JTX 2N6051JTXV 2N6052JAN	8186 6188 6188 6189 6190 6192 6193	2-19 2-19 2-8 2-4 2-4 2-4 2-4 2-4 2-4 2-4	3-16: 3-16: 3-17: 3-17: 3-17: 3-17: 3-17: 3-17:
2N5932 2N5933 2N5935 2N5936 2N5937 2N5954 2N5955 2N5956 2N5970 2N5971	6288 2 2	2N6338 2N6338 2N6341 2N6338 2N6341 2N6318 2N6317 2N6317 2N5882 2N5882	2-5 — 2-5 2-8 2-8 2-8 2-8 2-4 2-4	3-226 3-226 3-226 3-226 3-222 3-222 3-222 3-147 3-147	2N6052JTX 2N6052JTXV 2N6053 2N6054 2N6055 2N6056 2N6057 2N6058 2N6058JAN 2N6058JTX	2N6052JTX 2N6052JTXV 2N6053 2N6054 2N6055 2N6055 2N6057 2N6058 2N6058JAN 2N6058JTX	8212 2713 8726 8727 8728 8729 8230 8231 8231	2-4 2-4 2-3 2-3 2-3 2-3 2-4 2-4 2-4 2-4	3-172 3-176 3-176 3-176 3-176 3-172 3-172 3-172
2N5972 2N5974 2N5975 2N5976 2N5977 2N5978 2N5979 2N5980 2N5980 2N5981 2N5982	2N5974 2N5975 2N5976 2N5977 2N5978 2N5979	MJ15003 MJE2955* MJE2955* 2N5988*	2-5 2-11 2-11 2-11 2-11 2-11 2-11 2-11 2	3-1115 3-151 3-151 3-151 3-154 3-154 3-154 3-1132 3-1132 3-157	2N6058JTXV 2N6059 2N6059JAN 2N6059JTX 2N6059JTX 2N6059JTXV 2N6079 2N6078 2N6078 2N6079 2N6098 2N6099	2N6058JTXV 2N6059 2N6059JAN 2N6059JTX 2N6059JTXV 2N6077 2N6078	M AN	2-4 2-4 2-4 2-4 2-8 2-8 2-8 2-8 2-20 2-20	3-172 3-172 3-172 3-172 3-180 3-180 3-198 3-245 3-245

<sup>\*</sup> Consult factory if a direct replacement is necessary.

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#### INDEX-CROSS REFERENCE (Continued) (beunithoo) 30M3R373A 880R0-X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
2N6100 2N6101 2N6102 2N6103 2N6106 2N6107 2N6108 2N6109 2N6110 2N6111	2N6107 2N6109 2N6111 35.66	2N6487 2N6488 2N6488 2N6486 2N6107 2N6109 2N6111	2-20 2-20 2-20 2-20 2-19 2-19 2-19 2-19 2-18 2-18	3-237 3-237 3-237 3-237 3-182 3-182 3-182 3-182 3-182 3-182 3-182	2N6251 2N6253 2N6254 2N6257 2N6257 2N6258 2N6259 2N6260 2N6261 2N6262 2N6263	2N6251 2N6257 2N6257	2N5877 2N5878 2N5686 2N5631 2N4231A 2N4233A 2N5760 2N5050	2-4 2-3 2-3 2-5 2-5 2-4 2-8 2-8 2-2 2-8	3-201 3-140 3-140 3-48 3-129 3-118 3-64 3-64 3-133 3-88
2N6121 2N6122 2N6123 2N6124 2N6125 2N6125 2N6127 2N6128 2N6129 2N6130	2N6121 2N6122 2N6123 2N6124 2N6125 2N6126 2N6129 2N6130	2N6436 2N6338	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-5 2-5 2-5 2-19	3-185 3-185 3-185 3-185 3-185 3-185 3-241 3-226	2N6264 2N6270 2N6271 2N6272 2N6272 2N6273 2N6274 2N6274JAN 2N6274JTX 2N6274JTXV 2N6275	2N6274 2N6274JAN 2N6274JTX 2N6274JTXV 2N6275	2N5051 2N6338 2N6338 2N6338 2N6338 2N6338	2-8 ————————————————————————————————————	3-88 3-226 3-226 3-226 3-225 3-205 3-205 3-205 3-205
2N6131 2N6132 2N6133 2N6134 2N6175 2N6176 2N6177 2N6178 2N6179 2N6180	2N6131 2N6132 2N6133 2N6134	MPSU10 MPSU10 2N6559 MPSU06 MPSU05 MPSU56	2-19 2-12 2-12 2-13 2-12 2-12	3-1232 3-1232 3-277 3-1228 3-1228 3-1245	2N6276 2N6277 2N6277JAN 2N6277JTX 2N6277JTXV 2N6278 2N6279 2N6280 2N6281 2N6282	2N6276 2N6277 2N6277JAN 2N6277JTX 2N6277JTX 2N6277JTXV	2N6274 2N6275 2N6276 2N6277	2-29 2-29 2-29 2-29 2-29 2-6 2-6 2-6 2-29 2-29	3-205 3-205 3-205 3-205 3-205 3-205 3-205 3-205 3-205
2N6181 2N6186 2N6187 2N6188 2N6189 2N6190 2N6191 2N6191 2N6192 2N6193 2N6211	2N6186 2N6187 2N6188 2N6189 2N6190 2N6191 2N6192 2N6193 2N6211	MPSU55 Apple Band Band Band Band Band Band Band Band	2-7 2-7 2-7 2-7	3-1245 3-189 3-189 3-189 3-189 3-192 3-192 3-192 3-192 3-192 3-195	2N6283 2N6283JAN 2N6283JTX 2N6283JTXV 2N6284 2N6284JAN 2N6284JTX 2N6284JTXV 2N6285 2N6286	2N6283 2N6283JAN 2N6283JTX 2N6283JTXV 2N6284 2N6284JAN 2N6284JTX 2N6284JTXV 2N6285 2N6286	0886 1887 5868 8888 4888 8888 8888 8588	2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5	3-209 3-209 3-209 3-209 3-209 3-209 3-209 3-209 3-209
2N6212 2N6213 2N6226 2N6227 2N6228 2N6229 2N6230 2N6231 2N6233 2N6234	2N6212 2N6213 2N6226 2N6227 2N6228 2N6229 2N6230 2N6231 2N6233 2N6234	1052.1TX 1052.1TX 1053. 1054. 1055. 1057. 1058. 1058.4XV	2-8 2-2 2-2 2-2 2-3 2-3 2-3 2-8	3-195 3-195 3-133 3-133 3-133 3-122 3-122 3-122 3-198 3-198	2N6286JAN 2N6286JTX 2N6286JTXV 2N6287 2N6287JAN 2N6287JTX 2N6287JTXV 2N6288 2N6289 2N6290	2N6286JAN 2N6286JTX 2N6286JTXV 2N6287 2N6287JAN 2N6287JTX 2N6287JTXV 2N6288 2N6290	2N6288	2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-18 2-18 2-19	3-209 3-209 3-209 3-209 3-209 3-209 3-182 3-182 3-182
2N6235 2N6242 2N6243 2N6244 2N6245 2N6246 2N6247 2N6248 2N6249 2N6250	2N6235 2N6249 2N6250	MJ13015 MJ13334 MJ13333 MJ13334 2N5879 2N5880 MJ15016		3-198 3-966 3-1002 3-1002 3-1002 3-143 3-143 	2N6291 2N6292 2N6293 2N6294 2N6295 2N6295 2N6296 2N6297 2N6298 2N6298JAN 2N6298JTX	2N6292 2N6294 2N6295 2N6296 2N6297 2N6298 2N6298JAN 2N6298JTX	2N6290 2N6292	2-8 2-8	3-182 3-182 3-182 3-214 3-214 3-214 3-176 3-176

<sup>\*</sup> Consult factory if a direct replacement is necessary.

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# INDEX-CROSS REFERENCE (Continued) (beamings) 30/43/3439 220/35/34/1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2N6298JTXV 2N6299 2N6299JAN 2N6299JTX 2N6299JTXV 2N6300 2N6300JAN 2N6300JTXV 2N6300JTXV 2N6300JTXV 2N6301	2N6298JTXV 2N6299 2N6299JAN 2N6299JTX 2N6299JTXV 2N6300 2N6300JAN 2N6300JTXV 2N6300JTXV 2N6300JTXV	STAL STAL STAL STAL STAL STAL STAL STAL	2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-176 3-176 3-176 3-176 3-176 3-176 3-176 3-176 3-176 3-176	2N6378 2N6378JAN 2N6378JTX 2N6378JTXV 2N6379 2N6379JAN 2N6379JTX 2N6380 2N6381	2N6378 2N6378JAN 2N6378JTX 2N6378JTXV 2N6379 2N6379JAN 2N6379JTX 2N6379JTXV	2N6377 2N6378	2-6 2-6 2-6 2-6 2-6 2-6 2-6 2-6 2-6	3-229 3-229 3-229 3-229 3-229 3-229 3-229 3-229
2N6301JAN 2N6301JTX 2N6301JTXV 2N6302 2N6303 2N6306 2N6306JAN 2N6306JTX 2N6307 2N6308	2N6301JAN 2N6301JTX 2N6301JTXV 2N6303 2N6306 2N6306JAN 2N6306JTX 2N6307 2N6308	2N5630	2-8 2-8 2-8 2-4 2-27 2-3 2-3 2-3 2-3 2-3 2-3	3-176 3-176 3-176 3-118 3-32 3-218 3-218 3-218 3-218 3-218	2N6382 2N6383 2N6383JAN 2N6383JTX 2N6383JTXV 2N6384JAN 2N6384JAN 2N6384JTXV 2N6348JTXV 2N6348JTXV	2N6383 2N6383JAN 2N6383JTX 2N6383JTXV 2N6384 2N6384JAN 2N6384JTXV 2N6348JTXV 2N6348JTXV 2N6385	2N6379	2-6 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-229 3-233 3-233 3-233 3-233 3-233 3-233 3-233 3-233
2N6308JAN 2N6308JTX 2N6312 2N6313 2N6314 2N6315 2N6316 2N6317 2N6318 2N6322	2N6308JAN 2N6308JTX 2N6312 2N6313 2N6314 2N6315 2N6316 2N6317 2N6318	MJ10015	2-3 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-6	3-218 3-218 3-64 3-64 3-64 3-222 3-222 3-222 3-222 3-832	2N6385JAN 2N6385JTX 2N6385JTXV 2N6386 2N6387 2N6388 2N6406 2N6407 2N6408 2N6409	2N6385JAN 2N6385JTX 2N6385JTXV 2N6386 2N6387 2N6388	MJE171 MJE172 MJE181* MJE182*	2-3 2-3 2-19 2-19 2-10 2-10 2-10 2-10	3-233 3-233 3-237 3-237 3-237 3-1092 3-1092 3-1092 3-1092
2N6323 2N6324 2N6325 2N6325 2N6326 2N6327 2N6328 2N6329 2N6330 2N6331 2N6338	2N6326 2N6327 2N6328 2N6329 2N6330 2N6331 2N6338	MJ10015 MJ10015 MJ10015	2-6 2-6 2-6 2-5 2-5 2-6 2-5 2-5 2-6	3-832 3-832 3-832 	2N6410 2N6411 2N6412 2N6413 2N6414 2N6415 2N6416 2N6417 2N6418 2N6419	102 2-2 201 2-2 202 2-2 202 2-2 203 2-2 204 2-2 205 2-2 206 2-2 207 2-2 208 20	MJE200* MJE210 MJE180 MJE181 MJE170 MJE171 MJE243 MJE243 MJE253 MJE253	2-10 2-10 2-9 2-10 2-9 2-10 2-10 2-10 2-10 2-10	3-1096 3-1092 3-1092 3-1092 3-1102 3-1102 3-1102 3-1102
2N6338JAN 2N6338JTX 2N6338JTXV 2N6339 2N6340 2N6341 2N6341JAN 2N6341JTX 2N6341JTXV 2N6341JTXV	2N6338JAN 2N6338JTX 2N6338JTXV 2N6339 2N6340 2N6341 2N6341JAN 2N6341JTX 2N6341JTXV	2N6339	2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5	3-226 3-226 3-226 3-226 3-226 3-226 3-226 3-226 3-226 3-226 3-226	2N6420 2N6421 2N6422 2N6423 2N6424 2N6425 2N6436 2N6437 2N6437JAN 2N6437JTX	2N6420 2N6421 2N6422 2N6423 2N6424 2N6425 2N6436 2N6437 2N6437JAN 2N6437JTX	BREADN BRI BRI GRIJTX GRIP BRI BRI BRI BRI BRI BRI BRI BRI BRI BRI	2-8 2-8 2-8 2-8 2-8 2-5 2-5 2-5 2-5 2-5	3-20 3-20 3-20 3-37 3-37 3-241 3-241 3-241
2N6355 2N6356 2N6357 2N6358 2N6359 2N6371 2N6372 2N6373 2N6374 2N6377	2N6377	2N6057 2N6057 2N6058 2N6058 2N5885 2N5865 2N6569 2N6316 2N6315 2N6315	2-4 2-4 2-4 2-5 2-4 2-8 2-8 2-8 2-8	3-172 3-172 3-172 3-172 3-147 3-280 3-222 3-222 3-222 3-222 3-229	2N6437JTXV 2N6438 2N6438JAN 2N6438JTX 2N6438JTXV 2N6465 2N6466 2N6466 2N6467 2N6468 2N6469	2N6437JTXV 2N6438 2N6438JAN 2N6438JTX 2N6438JTX	MJ3247 MJ3247 MJ3237 MJ3237 2N5879	2-5 2-5 2-5 2-5 2-5 2-8 2-8 2-8 2-8 2-8	3-241 3-241 3-241 3-241 3-241 — — 3-154

<sup>\*</sup> Consult factory if a direct replacement is necessary.

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# INDEX-CROSS REFERENCE (Continued) (bounting) 20M3R373A 220A0 X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2N6470 2N6471 2N6472 2N6473 2N6474 2N6475 2N6476 2N6477 2N6477 2N6478 2N6478	2N6486	2N5881 2N5881 2N5882 FT317 FT317A FT417 FT417A FT317A FT317B	2-4 2-4 2-18 2-18 2-18 2-18	3-143 3-143 3-143 	2N6576 2N6577 2N6578 2N6579 2N6580 2N6581 2N6582 2N6583 2N6584 2N6591	2N6576 2N6577 2N6578	MJ13080 MJ13080 MJ16004 MJ13080 MJ13080 MJ16008	2-4 2-4 2-3 2-3 2-3 2-2 2-3 2-3 2-31 2-13	3-284 3-284 3-978 3-978 3-1030 3-978 3-1045 3-287
2N6487 2N6488 2N6489 2N6490 2N6491 2N6492 2N6493 2N6494 2N6494 2N6495 2N6494	2N6487 2N6488 2N6489 2N6490 2N6491	2N6055 2N6056 2N6056 2N6316 2N6339	2-20 2-20 2-20 2-3 2-3 2-3 2-8	3-245 3-245 3-176 3-176 3-176	2N6592 2N6593 2N6594 2N6609 2N6648 2N6648JAN 2N6648JTX 2N6648JTXV 2N6649 2N6649JAN	2N6592 2N6593 2N6594 2N6609 2N6648 2N6648JAN 2N6648JTX 2N6648JTXV 2N6649 2N6649JAN	AL POST TEXT TO THE PROPERTY OF THE PROPERTY OF THE PROPERTY PROPE	2-13 2-4 2-4 2-3 2-3 4 2-3	3-287 3-287 3-291 3-52 3-233 3-233 3-233 3-233 3-233
2N6497 2N6498 2N6499 2N6500 2N6510 2N6511 2N6511 2N6513 2N6514 2N6530	2N6497 2N6498 2N6499	2N5430 2N6306 2N6306 2N6544 2N6545 2N6544 TIP101	2-18 2-18 2-18 2-8 2-3 2-3 2-3 2-3 2-3 2-3 2-19	3-249 3-249 3-249 3-114 3-218 3-218 3-259 3-259 3-259 3-1274	2N6649JTX 2N6649JTXV 2N6650 2N6650JAN 2N6650JTX 2N6650JTX 2N6650JTX 2N6653 2N6654 2N6655 2N6666	2N6649JTX 2N6649JTXV 2N6650 2N6650JAN 2N6650JTX 2N6650JTXV	MJ13332 MJ13332 MJ13333		3-233 3-233 3-233 3-233 3-233 3-993 3-993 3-993
2N6531 2N6532 2N6534 2N6535 2N6536 2N6542 2N6543 2N6544 2N6544 2N6545 2N6546	2N6542 2N6543 2N6544 2N6545 2N6546	TIP102 TIP102 2N6301 TIP102 TIP102	2-19 2-19 2-8 2-19 2-19 2-19 2-2 2-2 2-3 2-3 2-4	3-1274 3-1274 3-1274 3-1274 3-1274 3-253 3-253 3-259 3-259 3-263	2N6667 2N6668 2N6669 2N6671 2N6672 2N6673 2N6674 2N6675 2N6676 2N6676	2N6667 2N6668 2N6676 2N6677	MJE15028 2N6544 MJ13080 MJ13080 MJ13090 MJ13090	VS 2-4	3-295 3-295 3-969 3-969 3-969 3-299 3-299
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2N6554 2N6555 2N6556 2N6557 2N6558 2N6559 2N6569 2N6573 2N6574 2N6575	2N6554 2N6555 2N6556 2N6557 2N6558 2N6559 2N6569	2N6546 2N6546	2-14 2-14 2-13	3-274 3-274 3-274 3-277 3-277 3-277 3-280 3-263 3-263 3-263	2SA505 2SA566 2SA613 2SA614 2SA616 2SA623 2SA624 2SA626 2SA627 2SA633	2057 22 2057 22 2058 22 2058 22 2018 22 2016 22 2016 22 2017 22 2018 23		2-8 2-8 2-8 2-8 2-8 2-14 2-14 2-2 2-2 2-14	3-78 3-20 3-189 3-133 3-41 3-706 3-133 3-133 3-706

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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
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	7037 2-18 9C 2-18 109 2-18 170 2-28 10 2-28	MJE253 2N3789	2-17 2-9 2-9 2-10 2-10 2-3 2-3 2-17 2-17	3-1256 3-78 3-78 3-1102 3-1102 3-56 3-56 3-1256 3-1256 3-1256	2SA1064 2SA1065 2SA1067 2SA1068 2SA1069 2SA1111 2SA1111 2SA1112 2SB502 2SB503	1975 2- 1976 2- 1976 2- 1980 2	2N6231 2N6231 2N6230 2N6231 TIP42B MJE350 MJE15031 MJE15031 2N3741 2N3741	2-3 2-3 2-3 2-18 2-9 2-19 2-19 2-8 2-8	3-122 3-122 3-122 3-122 3-120 3-1111 3-120 3-120 3-41 3-41
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#### INDEX-CROSS REFERENCE (Continued) (hounting) 30//283738 22080 X30///

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
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2SB569 2SB570 2SB571 2SB572 2SB573 2SB574 2SB575 2SB576 2SB577 2SB577	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	MJE3310 MJE3311 MJE3312 2N5193 2N5194 2N5195 2N5193 2N5194 2N5195 MJE2955	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-1134 3-1134 3-1134 3-94 3-94 3-94 3-94 3-94 3-94 3-1132	2SB718 2SB719 2SB720 2SB722 2SB723 2SB723 2SB724 2SB727 2SB744 2SB744 2SB750	227 227 22 23 24 24 24 24 24 24 24 24 24 24 24 24 24	MJE350 MJE15031 MJE15031 MJ15002 MJ15023 TIP32A MJE15029 MJE170 MJE172 TIP115	2-9 2-19 2-19 2-4 2-4 2-17 2-19 2-9 2-10 2-17	3-1112 3-1200 3-1200 3-1012 3-1020 3-1200 3-1200 3-109 3-109
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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2SC408 2SC409 2SC410 2SC411 2SC412 2SC412 2SC431 2SC432 2SC433 2SC434 2SC435	94 2-2 739 8-8 97 2-2 2205 2-2 6001 2-2 6001 2-2 182 211	MJ15011 2N6249 2N6249 2N6546 2N6546 2N6341 2N6341 MJ15022 MJ15022 MJ10000	2-4 2-4 2-4 2-4 2-5 2-5 2-5 2-4 2-4 2-5	3-1018 3-201 3-201 3-263 3-263 3-226 3-226 3-1020 3-781	2SC783 2SC789 2SC790 2SC791 2SC792 2SC793 2SC794 2SC794 2SC795 2SC806 2SC807	207 E3420 E3639 207 207 207 207 308 3739 3638	2N3738 2N6123 TIP31A 2N5050 2N5840 2N5758 2N5758 2N3739 MJ431 MJ413	2-8 2-18 2-17 2-8 2-2 2-2 2-2 2-8 2-3 2-3	3-37 3-185 3-125 3-88 3-137 3-133 3-37 3-740 3-740
2SC483 2SC487 2SC488 2SC489 2SC490 2SC491 2SC492 2SC493	182   2   10   2   2   2   2   2   2   2   2   2	MJ10000 2N3583 2N3583 2N6233 2N3441 2N3766 2N5050 2N4347 2N4347	2-5 2-8 2-8 2-8 2-8 2-8 2-8 2-9 2-2 2-2 2-3	3-790 3-20 3-20 3-198 3-13 3-44 3-88 3-15 3-15 3-15	2\$C808 2\$C825 2\$C833 2\$C840 2\$C840A 2\$C861 2\$C862 2\$C867 2\$C884 2\$C885	37.59 61.23 61.23 61.23 61.23 61.23 66.83 66.84 66.84 66.84 66.84	MJ411 2N3585 2N6235 2N5050 2N5051 MJ3029 MJ3030 2N3739 2N5050 2N6307	2-2 2-8 2-8 2-8 2-8 2-2 2-2 2-2 2-8 2-8	3-738 3-20 3-198 3-88 3-748 3-748 3-37 3-88 3-218
2SC495 2SC496 2SC508 2SC515 2SC518 2SC518A 2SC519A 2SC519A 2SC520 2SC520A	050 1-8 566 4-4 249 249 5607 3-8 5007 3	2N4923 2N4921 2N6233 2N3739 2N3448 2N3448 2N5759 2N5760 2N3448 2N3448	2-9 2-9 2-8 2-8 2-3 2-3 2-2 2-2 2-2 2-3 2-3	3-82 3-82 3-198 3-37 3-18 3-133 3-133 3-133 3-18 3-18	2SC886 2SC887 2SC888 2SC889 2SC895 2SC897 2SC898 2SC901 2SC901A 2SC902	\$634 (1501) \$5004 25010 257 257 257 257 2515 2515 2515	2N6306 MJ410 MJ410 MJ410 2N3441 2N5760 2N5760 2N6306 2N6306 2N5634	2-3 2-2 2-2 2-2 2-8 2-2 2-2 2-3 2-3 2-3	3-218 3-738 3-738 3-738 3-13 3-133 3-133 3-218 3-218
2SC521 2SC521A 2SC558 2SC588 2SC586 2SC642 2SC643 2SC646 2SC647 2SC664	0.000 0.000	2N3447 2N3448 MJ3029 2N3739 MJ410 BU204 BU204 2N3447 2N3448 2N5758	2-3 2-3 2-2 2-8 2-2 2-2 2-2 2-3 2-3 2-2	3-18 3-748 3-748 3-37 3-738 3-498 3-18 3-18 3-133	2SC931 2SC932 2SC935 2SC936 2SC937 2SC939 2SC940 2SC961 2SC962 2SC981	19014 8640 2004 12005 007 3 2553 2738 3736	MJE205 2N5977 2N5840 BU204 BU204 MJ15001 2N6249 2N5759 2N5758 2N5430	2-11 2-11 2-2 2-2 2-2 2-4 2-4 2-2 2-2 2-8	3-110 3-154 3-133 3-490 3-101 3-200 3-133 3-134
2SC675 2SC676 2SC677 2SC678	922	2N5760 2N6306 2N6306 2N6306 2N6306 2N3585 2N5052 MJ15011 2N3739 MJ410	2-2 2-3 2-3 2-3 2-3 2-8 2-8 2-8 2-4 2-8 2-2	3-133 3-218 3-218 3-218 3-218 3-20 3-133 3-1018 3-37 3-738	2SC999 2SC1004 2SC1004A 2SC1005 2SC1013 2SC1014 2SC1025 2SC1030 2SC1031 2SC1034	E 180 3798 3798 1207 1204 1208 17000 181 17000 1800	BU205 BU204 BU205 BU207 MDS26 MDS27 2N6233 2N5760 2N3585 BU204	2-2 2-2 2-2 2-14 2-14 2-8 2-2 2-8 2-2	3-490 3-490 3-490 3-732 3-732 3-198 3-133 3-20 3-490
2SC736 2SC758 2SC759 2SC760 2SC768 2SC769 2SC770 2SC771 2SC779 2SC778	10081 14000 14000 14000 14000 1400 1400		2-2 2-3 2-3 2-3 2-4 2-3 2-2 2-2 2-8 2-8	3-15 3-218 3-218 3-218 3-6 3-122 3-1018 3-37 3-37	2SC1046 2SC1050 2SC1051 2SC1055 2SC1059 2SC1060 2SC1061 2SC1078 2SC1079 2SC1080	5800   5600   6600   6600   70000   710000   710000   710000   710000   710000   710000   710000   710000   710000   710000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   7100000   71000000   71000000   71000000   71000000   71000000   710000000   7100000000   71000000000   710000000000	BU207 MJ411 2N5760 2N5430 2N3739 TIP31A TIP31A BU204 MJ15001 MJ15001	2-2 2-2 2-2 2-8 2-8 2-17 2-17 2-2 2-4 2-4	3-499 3-738 3-133 3-114 3-37 3-125 3-125 3-490 3-101

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#### INDEX-CROSS REFERENCE (Continued) (bounting) #204343434 82050 \( \text{CROSS} \)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
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2SC1105 2SC1106 2SC1107 2SC1108 2SC1109 2SC1110 2SC1111 2SC1111 2SC1112 2SC1113 2SC1114	8007 8007 8006 8007 8009 8009 8009 8000 8007	2N3739 2N5840 2N6123 2N6123 2N6123 2N6123 2N5634 2N5634 MJ3247 2N6542	2-8 2-2 2-18 2-18 2-18 2-18 2-3 2-3 2-3 2-8 2-2	3-37 3-137 3-185 3-185 3-185 3-185 3-122 3-122 3-752 3-253	2SC1382 2SC1391 2SC1402 2SC1403 2SC1409 2SC1410 2SC1413 2SC1418 2SC1419 2SC1429	10000 5583 5583 5523 5441 5441 647 647 647	MJE182 2N3739 2N5634 2N5634 TIP47 TIP47 BU207 TIP31 TIP31 MPSU01	2-10 2-8 2-3 2-3 2-17 2-17 2-2 2-17 2-17 2-17	3-1092 3-37 3-122 3-122 3-1270 3-1270 3-495 3-1256 3-1256 3-1220
2SC1115 2SC1116 2SC1124 2SC1125 2SC1130 2SC1131 2SC1132 2SC1140 2SC1141 2SC1142	8306  410  410  441  3441  545  576  530  6306  6304	2N5634 MJ15011 MPSU04 MPSU10 2N6543 2N6542 BU207 2N6547 2N6546 MJ13015	2-3 2-4 2-12 2-12 2-12 2-2 2-2 2-2 2-4 2-4 2-4	3-122 3-1018 3-1224 3-1232 3-253 3-253 3-263 3-263 3-263 3-966	2SC1431 2SC1433 2SC1434 2SC1436 2SC1440 2SC1441 2SC1444 2SC1445 2SC1447 2SC1448	8923 8921 8739 8739 8750 8760 8468	2N5050 MJ411 2N6546 2N6249 MJ15001 2N6249 2N5428 2N5430 TIP47 TIP47	2-8 2-2 2-4 2-4 2-4 2-8 2-8 2-17 2-17	3-88 3-738 3-263 3-201 3-1012 3-201 3-114 3-114 3-1270 3-1270
2SC1143 2SC1151 2SC1152 2SC1153 2SC1154 2SC1155 2SC1156 2SC1157 2SC1160 2SC1161		MJ13014 BU204 2N5840 BU204 MJ12003 D40D13 2N6543 2N6553 2N3738	2-3 2-2 2-2 2-2 2-30 2-13 2-2 2-14 2-8 2-8	3-966 3-490 3-137 3-490 3-944 3-702 3-253 3-270 3-37 3-37	2SC1449 2SC1450 2SC1454 2SC1456 2SC1463 2SC1466 2SC1468 2SC1469 2SC1477 2SC1501	2447 3009 3739 410 204 204 204 3447 345	MJE180 2N3583 MJ411 2N3739 2N6543 2N3585 MJ13091 MJ13091 MJ10006 MJE3439	2-9 2-8 2-2 2-8 2-2 2-8 2-4 2-4 2-5 2-9	3-1092 3-20 3-738 3-37 3-253 3-20 3-984 3-984 3-808 3-1136
2SC1162 2SC1167 2SC1168 2SC1170 2SC1170A 2SC1171 2SC1171 2SC1172 2SC1173 2SC1174 2SC1184	205 204 205 207 207 3527 6223 570 3585 704	MJE180 BU204 2N3739 BU207 BU207 BU204 BU208 TIP31 MJ12003 BU204	2-9 2-2 2-8 2-2 2-2 2-2 2-2 2-17 2-30 2-2	3-1092 3-490 3-37 3-495 3-495 3-490 3-495 3-1256 3-944 3-490	2SC1505 2SC1506 2SC1507 2SC1514 2SC1516 2SC1517 2SC1519 2SC1520 2SC1521 2SC1521	6306 6306 6306 6306 6306 6306 6306 6306	TIP48 TIP48 TIP48 MJE3439 MJE3300 2N4922 2N6557 2N6557 2N6557 MJ13091	2-17 2-17 2-17 2-9 2-10 2-9 2-13 2-13 2-13 2-4	3-1270 3-1270 3-1270 3-1136 3-1134 3-82 3-277 3-277 3-277 3-984
2SC1185 2SC1195 2SC1224 2SC1226 2SC1227 2SC1228 2SC1228 2SC1229 2SC1237 2SC1243 2SC1292	207 5780 5780 5730 51A 21A 21A 1204 1804 18001	2N5840 2N5838 2N6591 2N6548 MJ10006 MJ13091 MJ10006 TIP31B D40K3 2N5840	2-2 2-2 2-13 2-14 2-3 2-4 2-3 2-17 2-14 2-2	3-137 3-137 3-287 3-267 3-808 3-984 3-808 3-1256 3-710 3-137	2SC1577 2SC1578 2SC1579 2SC1580 2SC1580 2SC1584 2SC1585 2SC1586 2SC1609 2SC1610 2SC1617	8347 8306 8306 8338 8633 1601 1601 3738	MJ13091 MJ10014 MJ10013 MJ10014 2N6249 2N6249 2N6250 2N6340 2N6341 MJ411	2-4 2-4 2-4 2-4 2-4 2-4 2-5 2-5 2-5 2-2	3-984 3-826 3-826 3-826 3-201 3-201 3-201 3-226 3-226 3-238

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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorgla Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2SC1618 2SC1619 2SC1628 2SC1629 2SC1630 2SC1664 2SC1667 2SC1669 2SC1672 2SC1683	1760 1760 1760 1760 1760 1760 1760 1760	2N5758 2N5758 MPSU04 MJ1001 MPSU04 2N6300 2N5758 TIP47 2N6341 TIP47	2-2 2-2 2-12 2-3 2-12 2-8 2-2 2-17 2-5 2-17	3-133 3-133 3-1224 3-744 3-1224 3-176 3-133 3-1270 3-226 3-1270	2SC1985 2SC1986 2SC2024 2SC2027 2SC2068 2SC2071 2SC2073 2SC2080 2SC2085 2SC2121	2 10001 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP41B TIP41C 2N4923 MJ12005 D40N4 MJE3440 TIP47 MJE180 MJE2361T MJ411	2-18 2-18 2-9 2-2 2-13 2-9 2-17 2-9 2-17 2-2	3-1266 3-1266 3-82 3-952 3-714 3-1136 3-1270 3-1092 3-738
2SC1722 2SC1723 2SC1728 2SC1749 2SC1755 2SC1756 2SC1757 2SC1760 2SC1761 2SC1768	5758 5358 5358 5358 5756 5750 5750	TIP48 TIP48 MPSU07 MJE340 MLE2360T MJE2360T MJE2360T MPSU07 MPSU01 MJ3041	2-17 2-17 2-12 2-9 2-17 2-17 2-17 2-12 2-12 2-3	3-1270 3-1270 3-1232 3-1270 3-1128 3-1128 3-1128 3-1232 3-1220 3-750	2SC2122 2SC2123 2SC2126 2SC2127 2SC2128 2SC2138 2SC2139 2SC2140 2SC2147 2SC2148	12070 2 12070 2 10010 2 10010 2 10010 2 10015 2 10015 2 10015 2	MJ431 MJ10014 MJE13004 2N6249 MJ10015 MJ13091 MJ13091 MJ13091 MJ13091	2-3 2-4 2-18 2-4 2-6 2-4 2-4 2-6 2-4	3-740 3-826 3-1180 3-201 3-832 3-984 3-984 3-832 3-984
2SC1777 2SC1782 2SC1783 2SC1784 2SC1785 2SC1786 2SC1818 2SC1819 2SC1826 2SC1827	2760 2766 3756 3760 3758 3758 3758 3758 3750 3760	2N5882 MJ15001 2N6249 MJ15001 2N6249 2N6250 2N6340 MJE2361T TIP41B TIP41C	2-4 2-4 2-4 2-4 2-4 2-5 2-17 2-18 2-18	3-143 3-1018 3-201 3-1012 3-201 3-201 3-226 3-1128 3-1266 3-1266	2SC2151 2SC2159 2SC2167 2SC2168 2SC2189 2SC2190 2SC2191 2SC2198 2SC2198 2SC2198	16010 2 15016 2 16016 2 16016 2 11010 2 2227 2 2227 2 2009 2 16016 2 16016 2	MJ10014 MJ10015 MJE15030 MJE15030 MJ15001 2N6545 2N6547 2N6301 MJ11018 MJ10016	2-4 2-6 2-19 2-19 2-4 2-3 2-4 2-8 2-4 2-6	3-826 3-832 3-1208 3-1208 3-1012 3-259 3-263 3-176 3-933 3-832
2SC1829 2SC1830 2SC1831 2SC1832 2SC1846 2SC1847 2SC1848 2SC1866 2SC1868 2SC1869	7766 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	MJ3041 2N6578 2N6056 MJ10009 MJE180 MJE181 D40E7 2N5760 MJ13090 2N5634	2-3 2-4 2-3 2-5 2-9 2-10 2-14 2-2 2-4 2-3	3-750 3-284 3-176 3-814 3-1092 3-1092 3-706 3-133 3-984 3-122	2SC2209 2SC2220 2SC2229 2SC2230 2SC2233 2SC2235 2SC2236 2SC2238 2SC2238 2SC2239	13001 2 13001 2 13001 2 13001 2 13001 2 15001 2 1604 3	MJE181 MJ10016 TIP47 TIP47 2N6497 TIP47 TIP31 TIP47 2N5052 MJE2361T	2-6 2-6 2-17 2-17 2-18 2-17 2-17 2-17 2-8 2-17	3-1092 3-832 3-1270 3-1270 3-249 3-1270 3-1256 3-1270 3-88 3-1128
2SC1870 2SC1875 2SC1880 2SC1881 2SC1883 2SC1884 2SC1891 2SC1892 2SC1893 2SC1894	\$624 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6546 MJ12003 TIP112 TIP110 TIP122 2N6301 BU204 BU205 MJ12003 BU208	2-4 2-30 2-17 2-17 2-18 2-8 2-2 2-2 2-30 2-2	3-263 3-944 3-1278 3-1278 3-1281 3-176 3-490 3-490 3-984 3-495	2SC2243 2SC2244 2SC2245 2SC2246 2SC2247 2SC2248 2SC2249 2SC2250 2SC2250	\$634 2 2 2 3 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	2N6543 2N6545 MJ13091 2N6547 2N6543 2N6545 MJ10015 MJ10016 2N6249 2N6249	2-3 2-3 2-4 2-4 2-3 2-4 2-6 2-6 2-4 2-4	3-253 3-259 3-984 3-263 3-253 3-259 3-832 3-832 3-201 3-201
2SC1895 2SC1896 2SC1903 2SC1904 2SC1905 2SC1922 2SC1929 2SC1942 2SC1983 2SC1984	1758 1768 1767 1767 1768 1768 1768 1768 176	MJ12005 MJ12005 MJE341 MJE341 MJE2361T MJ12003 TIP48 MJ12003 TIP111 TIP112	2-2 2-9 2-9 2-9 2-17 2-3 2-17 2-30 2-17 2-17	3-952 3-952 3-1110 3-1110 3-1128 3-944 3-1270 3-944 3-1278 3-1278	2SC2261 2SC2262 2SC2270 2SC2278 2SC2292 2SC2293 2SC2293 2SC2293 2SC2311 2SC2321 2SC2321	2780 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6249 2N6249 2N5194 MJE3439 MJ13091 MJ13091 MJE270 2N4922 2N5634 MJ15015	2-4 2-4 2-10 2-9 2-4 2-9 2-9 2-3 2-4	3-201 3-201 3-94 3-1136 3-984 3-1106 3-82 3-122 3-9

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#### INDEX-CROSS REFERENCE (Continued) (beenthood) 30M393439 32090 430M

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
2\$C2323 2\$C2324 2\$C2331 2\$C2333 2\$C2334 2\$C2335 2\$C2337 2\$C2344 2\$C2354 2\$C2356	418 410 1276 1276 1347 1347 147 150 150 415	MJ15001 2N6038 MJE13004 MJE13005 MJE15030 MJE15030 MJE13007 2N5634 TIP47 2N3739 MJ13091	2-4 2-10 2-18 2-18 2-19 2-19 2-3 2-17 2-8 2-4	3-1012 3-161 3-1180 3-1180 3-1208 3-1186 3-112 3-1270 3-37 3-984	2SD26B 2SD26C 2SD28 2SD29 2SD041 2SD45 2SD46 2SD47 2SD49 2SD50	8753   5 9788   3 9788   2 9390   3 9390   3 9378   3 977   2 8341   3	2N5758 2N5760 2N3767 2N3767 2N3767 2N5760 2N5760 2N5760 2N5758 2N5050 2N5758	2-2 2-8 2-8 2-8 2-3 2-2 2-2 2-2 2-8 2-2	3-133 3-133 3-44 3-44 3-26 3-133 3-133 3-88 3-133
2SC2357 2SC2358 2SC2366 2SC2371 2SC2373 2SC2388 2SC2387 2SC2402 2SC2403 2SC2403 2SC2428	1,000 1,000	MJ12010 MJ12010 MJ10016 MJE3439 MJE13006 2N6543 MJE3055T 2N6546 MJ10015 2N6249	2-4 2-4 2-6 2-9 2-19 2-2 2-11 2-4 2-6 2-4	3-984 3-984 3-832 3-1136 3-1136 3-253 3-1136 3-263 3-832 3-201	2SD51 2SD52 2SD53 2SD55 2SD56 2SD57 2SD68 2SD60 2SD67 2SD68	## 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N5758 2N5758 2N5759 2N6328 2N3738 2N3766 2N3766 2N5760 2N5759 2N5758	2-2 2-2 2-2 2-6 2-8 2-8 2-8 2-2 2-2 2-2	3-133 3-133 3-133 — 3-37 3-44 3-133 3-133
2SC2429 2SC2430 2SC2431 2SC2432 2SC2432 2SC2434 2SC2435 2SC2436 2SC2442 2SC2443	100 4 100 100 100 100 100 100 100 100 10	MJ16010 2N5633 MJ15015 2N5882 MJ11016 2N6327 2N6059 2N6059 MJ10016 MJ10016	2-6 2-3 2-4 2-4 2-6 2-5 2-4 2-4 2-6 2-6	3-1060 3-122 3-832 3-143 3-931 — 3-172 3-172 3-832 3-832	2SD69 2SD70 2SD71 2SD73 2SD73 2SD74 2SD80 2SD81 2SD82 2SD83 2SD83	15802 15001	2N5760 2N3766 2N5050 2N5758 2N5760 2N5758 2N5758 2N5758 2N5758 2N5750 MJ15011	2-2 2-8 2-8 2-2 2-2 2-2 2-2 2-2 2-2 2-2	3-133 3-44 3-88 3-133 3-133 3-133 3-133 3-131
2SC2448 2SC2449 2SC2450 2SC2451 2SC2452 2SC2453 2SC2482 2SC2487 2SC2488 2SC2489	91007 1007 1007 1007 1007 1007 1007 1007	MJ13091 MJ13091 MJ13091 MJ13091 MJ13091 MJ13091 MJE2361T 2N5634 2N5634 2N5634	2-4 2-4 2-4 2-4 2-4 2-17 2-3 2-3 2-3	3-984 3-984 3-984 3-984 3-984 3-984 3-1128 3-122 3-122 3-122	2SD88 2SD90 2SD91 2SD92 2SD93 2SD94 2SD102 2SD103 2SD107 2SD108	5041 5056 10008 10008 2180 2180 2180 13090 13090 13090 13090	2N5758 2N3766 2N3766 2N3583 2N5051 2N5052 2N3583 2N5050 2N6056 2N6056	2-2 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-3 2-3	3-133 3-44 3-44 3-20 3-88 3-88 3-20 3-88 3-176 3-176
2SC2492 2SC2493 2SC2500 2SC2516 2SC2534 2SC2535 2SC2536 2SC2541 (TO218) 2SC2562	124 176-7 146-7 146-7 170-7 1810-7 148-7 148-7 148-7	2N5634 2N5634 TIP31 2N6497 MJE13003 MJE13005 2N6499 MJ13091 TIP42A	2-3 2-3 2-17 2-18 2-9 2-18 2-18 2-4 2-18	3-122 3-122 3-1256 3-249 3-1180 3-1180 3-249 3-984 3-1266	2SD110 2SD111 2SD113 2SD114 2SD116 2SD117 2SD118 2SD119 2SD124 2SD124A	\$508 2 172 2 170 2 122 2 122 2 204 2 204 2 208 2 208 2 208 2	2N5634 2N5632 MJ802 2N5686 2N5758 2N5760 2N5760 2N5758 2N5758 2N5758	2-3 2-3 2-6 2-6 2-2 2-2 2-2 2-2 2-2 2-2	3-122 3-733 3-133 3-133 3-133 3-133 3-133
2SC2569 2SC2590 2SD12 2SD15 2SD16 2SD17 2SD18 2SD24 2SD26 2SD26A	3248 5340 5184 5184 5184 5184 5184 5184 5184 5184	2N5760 MJE341 2N5758 2N5758 2N5758 2N5760 MJ15011 2N3739 2N5758 2N5758	2-9 2-2 2-2 2-2 2-2 2-2 2-2 2-8 2-2 2-2	3-133 3-1110 3-133 3-133 3-133 3-133 3-1018 3-37 3-133 3-133	2SD125 2SD125A 2SD126A 2SD129 2SD130 2SD131 2SD132 2SD138 2SD138 2SD139 2SD141	12006 2 12006 2 12006 2 12006 2 12003 2 12009 2 110 2 110 2	2N5758 2N5758 2N5760 2N3767 2N3766 2N5758 2N6338 2N3738 2N3739 2N3766	2-2 2-2 2-2 2-8 2-8 2-2 — 2-8 2-8 2-8	3-133 3-133 3-144 3-44 3-133 3-226 3-37 3-37

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#### INDEX-CROSS REFERENCE (Continued) (beautitated) 30M3H3338 220804X3034

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2SD142 2SD143 2SD144 2SD146 2SD147 2SD148 2SD150 2SD151 2SD151 2SD152 2SD154	2000 2000 2000 2000 2000 2000 2000 200	2N3766 2N3767 2N3767 2N4912 2N4912 2N4912 2N49583 2N5632 2N3583 2N3767	2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-3 2-8 2-8	3-44 3-44 3-44 3-75 3-75 3-20 3-122 3-20 3-44	2SD246 2SD247 2SD249 2SD250 2SD251 2SD254 2SD255 2SD256 2SD257 2SD258	18015 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	BU208 2N5758 2N5302 2N6328 2N5052 2N3767 2N3766 2N3767 MJ3247	2-2 2-2 2-5 2-6 2-8 2-8 2-8 2-8 2-8 2-8	3-495 3-133 3-98  3-88 3-44 3-44 3-44 3-752
2SD155 2SD156 2SD157 2SD158 2SD159 2SD161 2SD163 2SD164 2SD165 2SD166	13091 2 10045 2 13099 2 124 2 172 2 172 2 172 2 1732 2 1732 2 1732 2 1732 2 1733 2	2N3767 2N3738 2N3739 2N3738 2N3739 2N5633 2N3715 2N5632 2N5634 MJ15011	2-8 2-8 2-8 2-8 2-8 2-3 2-3 2-3 2-3 2-3	3-44 3-37 3-37 3-37 3-122 3-26 3-122 3-1018	2SD259 2SD260 2SD262 2SD265 2SD266 2SD271 2SD272 2SD273 2SD274 2SD283	1845 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	MJ3248 2N5758 2N6546 2N6545 2N6545 MJE13005 MJE13005 2N6545 2N6545 MJ3247	2-8 2-2 2-4 2-3 2-3 2-18 2-18 2-3 2-3 2-8	3-752 3-133 3-263 3-259 3-259 3-1180 3-259 3-259 3-752
2SD168 2SD171 2SD172 2SD173 2SD174 2SD175 2SD176 2SD177 2SD180 2SD181	1039 2-129 2-139 2-1395 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300 2-1300	2N6385 2N6543 2N5877 2N5632 2N5877 2N5632 2N5632 2N5634 2N5758 MJ15001	2-3 2-2 2-3 2-3 2-3 2-3 2-3 2-3 2-2 2-2	3-233 3-253 3-140 3-122 3-140 3-122 3-122 3-122 3-133 3-1018	2SD284 2SD285 2SD286 2SD287 2SD288 2SD289 2SD290 2SD291 2SD292 2SD293	31A 2 32A 2 12005 2 1716 2 1716 2 17016 2 10016 3 10016 2 10331 2	MJ3247 MJ3247 MJ15011 MJ15011 TIP31B TIP31B 2N5428 2N3767 2N3767 2N3767	2-8 2-8 2-2 2-2 2-17 2-17 2-8 2-8 2-8 2-4	3-752 3-752 3-1018 3-1018 3-1256 3-1256 3-114 3-44 3-44 3-263
2SD188 2SD189 2SD189A 2SD198 2SD199 2SD200 2SD201 2SD202 2SD203 2SD206	1821   2   2   2   2   2   2   2   2   2	2N5758 2N5758 2N5758 2N5758 2N5840 BU204 2N5758 2N5759 2N5760 2N5760	2-2 2-2 2-2 2-2 2-2 2-2 2-2 2-2 2-2 2-3	3-133 3-133 3-137 3-490 3-490 3-133 3-133 3-133 3-140	2SD294 2SD295 2SD296 2SD297 2SD299 2SD300 2SD301 2SD311 2SD311 2SD312	2 1234 2 205 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6547 MJ13335 MJ13335 MJ3248 MJ12004 MJ12004 2N6385 2N6547 2N6547 2N6543	2-4 2-5 2-5 2-8 2-2 2-2 2-3 2-4 2-4 2-2	3-263 3-1002 3-1002 3-752 3-946 3-946 3-233 3-263 3-263 3-253
2SD207 2SD208 2SD211 2SD212 2SD213 2SD214 2SD217 2SD218 2SD226 2SD231	26045 2 2005 2 391 22 391 2 391 2 305 2 3059 2 3069 2 3003 2	2N5632 2N5634 2N5877 2N5632 2N5633 2N5634 2N5633 2N5634 2N5634 2N3766 2N5302	2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-8 2-5	3-122 3-122 3-140 3-122 3-122 3-122 3-122 3-422 3-44 3-98	2SD313 2SD314 2SD315 2SD316 2SD317 2SD318 2SD319 2SD320 2SD321 2SD322	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP31A TIP31A 2N3766 2N3716 TIP31A TIP31A 2N5633 2N5840 2N6306 MJ4247	2-17 2-17 2-8 2-8 2-17 2-17 2-3 2-2 2-3 2-3	3-1256 3-1256 3-44 3-26 3-1256 3-1256 3-122 3-137 3-218 3-752
2SD232 2SD234 2SD235 2SD236 2SD237 2SD238 2SD241 2SD242 2SD243 2SD244	20015 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6275 TIP31A TIP31A 2N4912 2N4912 2N3583 2N3766 2N3767 MJ3247 MJ3248	2-6 2-17 2-17 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-205 3-1256 3-1256 3-75 3-75 3-20 3-44 3-44 3-752 3-752	2SD323 2SD324 2SD325 2SD326 2SD330 2SD331 2SD334 2SD335 2SD338 2SD339	# 150	MJ4248 2N3739 TIP31 2N3739 TIP31A TIP31A 2N5759 2N5758 2N5758 2N5758	2-3 2-8 2-17 2-8 2-17 2-17 2-2 2-2 2-2 2-2	3-752 3-37 3-1256 3-37 3-1256 3-1256 3-133 3-133 3-133

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# INDEX-CROSS REFERENCE (Continued) (beuntino) 30/393939 82093 (30/4)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2SD340 2SD341 2SD342 2SD343 2SD344 2SD345 2SD346 2SD346 2SD347 2SD348 2SD350	203 5755 5302 5326 5326 5767 7767 7766 424	MJ15015 MJ15015 TIP31B TIP31B TIP31B TIP31B TIP41A TIP41A MJ12005 MJ12004	2-4 2-4 2-17 2-17 2-17 2-17 2-18 2-18 2-2 2-2	3-9 3-9 3-1256 3-1256 3-1256 3-1266 3-1266 3-952 3-946	2SD427 2SD428 2SD429 2SD430 2SD431 2SD432 2SD433 2SD434 2SD435 2SD436	1767 2 2 1767 2 1767 2 1767 2 2 1612 2 2 1663 2 2 1663 2 2 1665 2 1665 2 1665 2 2 1665 2 1665 2 1665 2 2 1665 2 1665 2 2 1665 2 2 1665 2 2 1665 2 2 1665 2 2 1665 2 2 1665 2 2	2N5759 2N5758 2N6547 2N5759 2N5633 2N5634 MJ15011 MJ13330 MJ13332 MJ13333	2-2 2-2 2-4 2-2 2-3 2-3 2-2 2-5 2-5 2-5	3-133 3-133 3-263 3-133 3-122 3-1018 3-996 3-996 3-1002
2SD351 2SD353 2SD356 2SD357 2SD358 2SD359 2SD360 2SD361 2SD363 2SD364	320P 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	2N6545 2N5838 2N4923 2N4923 2N4923 2N5190 2N5190 2N5191 MJ10015 MJ10016	2-3 2-2 2-9 2-9 2-9 2-10 2-10 2-10 2-6 2-6	3-259 3-137 3-82 3-82 3-82 3-90 3-90 3-90 3-832 3-832	2SD437 2SD457 2SD458 2SD459 2SD460 2SD461 2SD463 2SD464 2SD475 2SD476	7767 2 7786 2 7739 2 7739 2 7739 2 7739 2 7745 2 7834 2 7834 2	MJ13091 MJ10015 MJ13091 TIP121 TIP122 MJ411 2N6056 2N6056 2N6056 2N6122 2N6123	2-4 2-6 2-4 2-18 2-18 2-2 2-3 2-3 2-18 2-18	3-984 3-832 3-984 3-128 3-138 3-176 3-176 3-185
2SD365 2SD366 2SD368 2SD369 2SD371 2SD372 2SD373 2SD374 2SD375 2SD376	2247 2 2247 2 2001 2 1001 2 1007 2 1007 2 1707 2 1567 2	TIP31A TIP31A MJ12005 2N3716 2N5758 MJ10015 MJ10016 MJ13330 MJ13331	2-17 2-17 2-2 2-3 2-2 2-6 2-6 2-6 2-5 2-5	3-1256 3-1256 3-952 3-26 3-133 3-832 3-832 3-832 3-996 3-996	2SD478 2SD479 2SD480 2SD481 2SD482 2SD483 2SD484 2SD485 2SD486 2SD487	1098 2 1077 2 10	TIP47 2N6037 2N6038 2N6039 2N5655 2N5656 2N5657 2N5190 2N5191 2N5192	2-17 2-10 2-10 2-10 2-9 2-9 2-9 2-10 2-10	3-127 3-161 3-161 3-126 3-126 3-126 3-90 3-90
2SD377 2SD379 2SD380 2SD381 2SD382 2SD382 2SD383 2SD384 2SD385 2SD386 2SD387	13677 2 13255 2 13255 2 12064 2 13064 2 1367 2 1547 2 1547 2 1547 2	MJ13334 2N5758 MJ12005 MJE15030 MJE15030 MJ411 2N6301 2N6301 MJE13004 MJE13004	2-5 2-2 2-2 2-19 2-19 2-2 2-8 2-8 2-18 2-18	3-1002 3-133 3-952 3-1208 3-1208 3-738 3-176 3-176 3-1180 3-1180	2SD488 2SD489 2SD490 2SD491 2SD492 2SD493 2SD494 2SD495 2SD496 2SD497	7758 2 7758 2 7758 2 204 2 204 7 204 7 2759 2 37759 2	2N4921 2N4922 2N4923 MJE3055 2N3055 2N5977 2N5978 2N5979 MJE6043 MJE6044	2-9 2-9 2-9 2-11 2-4 2-11 2-11 2-11 2-11	3-82 3-82 3-813 3-6 3-154 3-154 3-165 3-165
2SD388 2SD389 2SD390 2SD393 2SD394 2SD395 2SD396 2SD401 2SD402 2SD402	21A 22 23 23 23 23 23 23 23 23 23 23 23 23	MJ4247 TIP31A TIP31A MJ13091 MJ13091 MJ13091 2N6547 TIP47 TIP47 TIP120	2-3 2-17 2-17 2-4 2-4 2-4 2-4 2-18 2-18 2-18	3-752 3-1256 3-1256 3-984 3-984 3-984 3-263 3-1266 3-1266 3-1281	2SD498 2SD499 2SD500 2SD501 2SD502 2SD503 2SD504 2SD505 2SD506 2SD517	15(32 2) 16(34 2) 16(32 2) 16(32 3) 16(34 2) 16(34 2) 16(	MJE6045 MJE3055 MJE3055 2N5991 2N6055 2N6056 2N6057 2N6058 2N6059 MJ12003	2-11 2-11 2-11 2-11 2-3 2-3 2-4 2-4 2-4 2-30	3-165 3-113; 3-113; 3-157 3-176 3-176 3-172 3-172 3-944
2SD414 2SD415 2SD416 2SD417 2SD418 2SD422 2SD422 2SD423 2SD424 2SD425 2SD426	A248	MJE341 MJE341 MJ12005 2N6306 MJ12005 MJE13004 MJE13004 MJ15001 2N5634 2N5633	2-9 2-9 2-2 2-3 2-2 2-18 2-18 2-4 2-3 2-3	3-1110 3-952 3-218 3-952 3-1180 3-1180 3-1012 3-122 3-122	2SD518 2SD519 2SD522 2SD523 2SD523 2SD524 2SD525 2SD526 2SD531 2SD531 2SD533 2SD538	2775   2   31A   24   31A   24   31A   24   31A   24   31B   24   32A   24   32A   24	MJE13004 MJ13015 2N5632 2N6055 2N6056 TIP41C TIP41B TIP41C MJ423 MJ13091	2-18 2-4 2-3 2-3 2-3 2-18 2-18 2-18 2-3 2-4	3-1180 3-966 3-122 3-176 3-1266 3-1266 3-1266 3-740 3-984

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beunings) 30/43/83/33 280/93/83/41

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
2SD539 2SD544 2SD552 2SD553 2SD554 2SD554 2SD556 2SD570 2SD572 2SD573		TIP41C 2N6250	2-4 2-18 2-4 2-18 2-8 2-4 2-12 2-18 2-4 2-4	3-966 3-1266 3-201 3-1266 3-20 3-966 3-1230 3-185 3-826 3-826	2SD692 2SD693 2SD694 2SD695 2SD696 2SD702 2SD703 2SD706 2SD707	20027 24 61908 24 6290 24 6393 2 6495 2 6495 2 6496 2 6496 2 6496 2 6496 2 6496 2	MJ10013	2-3 2-3 2-6 2-6 2-6 2-6 2-6 2-3 2-4 2-4	3-176 3-822 3-832 3-832 3-832 3-832 3-832 3-826 3-826
2SD574 2SD577 2SD589 2SD597 2SD598 2SD600 2SD604 2SD604 2SD606 2SD608	239 239 24 25 25 25 25 25 25 25 25 25 25 25 25 25	MJ12005 2N5758 2N5759 2N4923	19 2-4	3-832 3-946 3-952 3-133 3-133 3-82 3-750 3-750 3-826 3-1270	2SD708 2SD709 2SD710 2SD716 2SD717 2SD718 2SD721 2SD722 2SD722 2SD723 2SD724	22 2006 22 2004 22 2004 22 2004 22 2004 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 22 2005 2005 22 2005 2		2-4 2-3 2-5 2-18 2-20 2-19 2-19 2-19 2-17 2-18	3-826 3-750 3-802 3-126 3-725 3-165 3-165 3-125 3-118
2SD610 2SD612 2SD613 2SD622 2SD626 2SD627 2SD627 2SD628 2SD629 2SD630 2SD631	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP47 MJE520 TIP41C MJE13005 MJ10012 MJ12004 2N6059 2N6059 2N5302 2N5302	2-9 2-18 2-18 2-3 2-2 2-4 2-4 2-5	3-1270 3-1256 3-1266 3-1180 3-822 3-946 3-172 3-172 3-98 3-98	2SD725 2SD726 2SD727 2SD728 2SD729 2SD731 2SD732 2SD733 2SD748 2SD749	22 22 22 22 22 22 22 22 22 22 22 22 22	MJ12005 TIP31C 2N4347 2N5760 2N6284 2N6306 2N6306 MJ15001 2N5838 2N6543	2-2 2-17 2-2 2-2 2-5 2-3 2-3 2-4 2-3 2-2	3-952 3-125 3-32 3-133 3-209 3-176 3-101 3-137 3-253
2SD632 2SD633 2SD634 2SD635 2SD640 2SD642 2SD643 2SD644 2SD645 2SD646	S S S S S S S S S S S S S S S S S S S	2N5840 TIP122 TIP121 TIP120 2N6545 MJ10016 MJ10016 MJ10016 MJ10016 MJ10016	2-18 2-18 2-18 2-4 2-6 2-6 2-6 2-6 2-6	3-137 3-1281 3-1281 3-1281 3-259 3-832 3-832 3-832 3-832 3-832 3-832	2SD751 2SD752 2SD753 2SD757 2SD758 2SD759 2SD760 2SD761 2SD762 2SD764	RAP   2   2   2   3   3   3   3   3   3   3	MJ15001 2N6249	2-3 2-4 2-4 2-9 2-9 2-17 2-17 2-17 2-17	3-740 3-101 3-201 3-113 3-113 3-127 3-127 3-125 3-938
2SD649 2SD650 2SD663 2SD665 2SD668 2SD668 2SD669 2SD670 2SD672 2SD673 2SD674		2N5759	2-3 2-3 2-4 2-9 2-9	3-946 3-750 3-750 3-201 3-1110 3-1110 3-284 3-137 3-133 3-133	2SD765 2SD766 2SD768 2SD798 2SD794 2SD797 2SD800 2SD801 2SD802 2SD803	31 2 24 2 10 2 10 2 10 2 11 2 11 2 11 2 11 2 11	MJ12003 2N3739 2N6045 MJE180 MJE182 MJE802 2N5840 2N6545 2N6059	2-30 2-8 2-19 2-9 2-10 2-9 2-3 2-3 2-3 2-4	3-944 3-37 3-165 3-109: 3-111 3-137 3-259 3-259 3-172
2SD675 2SD676 2SD677 2SD678 2SD679 2SD686 2SD687 2SD689 2SD689 2SD690 2SD691		2N5760 2N6543 TIP110 TIP111	2-17 2-18 2-17 2-8	3-133 3-133 3-233 3-1278 3-1278 3-1281 3-111 3-1278 3-114 3-176	2SD805 2SD811 2SD823 2SD836 2SD836 2SD837 2SD839	1240 2 8543 2 846 2 8546 2 410 2	MJ12010 MJE15030 TIP110 TIP120 MJE800T	2-6 2-4 2-19 2-17 2-18 2-18	3-832 3-263 3-112 3-127 3-128 3-111

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beambreo) 30MR93R3A 230R0-/230MI

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
2SD840 2SD843 2SD844 2SD867 2SD872 2SD872 2SD873 2SD877 2SD878 2SD880 2SD882	3056 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	MJE802T MJE15028 2N6290 2N5633 2N6499 2N3773 2N3441 2N3055 TIP31A MJE180	2-18 2-19 2-19 2-3 2-18 2-4 2-8 2-4 2-17 2-17	3-111 3-1208 3-182 3-122 3-249 3-52 3-13 3-6 3-1256 3-1092	40875 40876 40885 40886 40887 40910 40911 40912 40913 41012	13015 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP41C TIP41A MPSU10 MPSU10 2N6559 2N4231A 2N4233A 2N5050 2N5051 2N5038	2-18 2-18 2-12 2-12 2-13 2-8 2-8 2-8 2-8 2-8 2-5	3-1266 3-1236 3-1237 3-1237 3-64 3-64 3-88 3-88 3-86
2SD903 2SD950 2SD951 2SD952 2SD952 2SD953 40250 40251 40310 40312 40313	10013 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	MJ12005 MJ12004 MJ12004 MJ12005 2N4231A 2N6569 2N4231A 2N4232A 2N4232A	2-2 2-2 2-2 2-2 2-2 2-8 2-4 2-8 2-8 2-8	3-952 3-946 3-946 3-946 3-952 3-64 3-280 3-64 3-64 3-20	41013 41500 41501 41504 41505 41506 43104 BD127 BD128 BD129	BD157 BD158 BD159	2N6339 TIP29 TIP30 TIP31 MPSU10 2N6543 2N5631	2-5 2-17 2-17 2-17 2-12 2-2 2-4 2-9 2-9 2-9	3-226 3-125- 3-125- 3-125- 3-123- 3-253 3-118 3-336 3-336
40316 40318 40322 40324 40325 40328 40363 40364 40369 40372	17005 0 110 0 140 0 1400 0 1784 2 1784 2 1500 0 1500 0 1500 0	2N4231A 2N4240 2N4240 2N4231A 2N6569 2N4240 2N5877 2N4233A 2N5877 2N3054	2-8 2-8 2-8 2-8 2-4 2-8 2-3 2-8 2-3 2-8	3-64 3-20 3-20 3-64 3-280 3-20 3-154 3-64 3-154 3-2	BD130 BD131 BD132 BD133 BD135 BD135-10 BD135-16 BD136-6 BD136 BD136-10	2N3055 BD785 BD786 BD787 BD135 BD139-10 BD139-16 BD139-6 BD136 BD140-10	TIP FIRST MAL MAL MAL 201 201 201 201 201 201 201 201 201 201	2-4 2-10 2-10 2-10 2-10 — 2-9 2-9 2-9 — 2-9	3-6 3-428 3-428 3-332 3-332 3-332 3-334 3-334
40373 40374 40375 40411 40513 40514 40542 40543 40613 40618	120 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N3441 2N3583 2N5428 MJ802 MLE3055T MJE3055T 2N5978 2N5978 TIP31 TIP31	2-8 2-8 2-8 2-6 2-11 2-11 2-3 2-3 2-17 2-17	3-13 3-20 3-114 3-742 3-1132 3-1132 3-154 3-154 3-1256 3-1256	BD136-16 BD136-6 BD137-10 BD137-16 BD137-16 BD138-10 BD138-16 BD138-16	BD140-16 BD137 BD139-10 BD139-16 BD139-6 BD138 BD140-10 BD140-16 BD140-6	200 万里	2-9 2-9 2-9 2-9 2-9 2-9 2-9 2-9	3-334 3-332 3-332 3-332 3-334 3-334 3-334
40621 40622 40624 40627 40629 40630 40631 40632 40636 40829	12038 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	TIP31 TIP31 TIP41A TIP41A TIP31 TIP31 TIP31A TIP31A TIP41A 2N5878 2N6316	2-17 2-18 2-18 2-18 2-17 2-17 2-17 2-18 2-3 2-8	3-1256 3-1256 3-1266 3-1266 3-1256 3-1256 3-1256 3-1266 3-140 3-222	BD139 BD140 BD140 BD142 BD142-4 BD142-6 BD142-7 BD157 BD158 BD159	BD139 BD140 BD180 2N3055 2N3055-6 2N3055-7 BD157 BD158 BD159	AA M. M. AA AA M. AA AA AA AA AA AA AA AA AA AA AA AA AA	2-10 2-4 2-4 2-4 2-4 2-9 2-9 2-9	3-332 3-334 3-6 3-6 3-6 3-336 3-336 3-336
40830 40831 40850 40852 40853 40854 40871 40872 40873 40874	10016 10017 10008 10008 1008 1008 1008	2N6315 2N6315 2N4240 2N6543 2N6546 2N6546 TIP41C TIP42C TIP41B TIP41B	2-8 2-8 2-8 2-2 2-4 2-4 2-18 2-18 2-18 2-18	3-222 3-222 3-220 3-253 3-263 3-1266 3-1266 3-1266 3-1266	BD165 BD166 BD167 BD168 BD169 BD170 BD175 BD175-10 BD175-16 BD175-6	BD166 BD167 BD168 BD169 BD170	RIT RIT AM RIT RIS	2-9 2-9 2-9 2-9 2-9 2-9 — 2-10 2-10 2-9	3-338 3-340 3-338 3-340 3-342 3-342 3-342 3-342

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beautitro0) 30M3R343R 320R0-X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
BD176 BD176-10 BD176-16 BD176-6 BD177 BD177-10 BD177-16 BD177-6 BD178 BD178-10	BD176 BD180-10 BD180-16 BD180-6 BD177 BD179-10 BD179-16 BD179-6 BD178 BD178	5200 6210 735 736 737 738 730 730	2-10 2-10 2-9  2-10 2-10 2-10 2-10 2-10	3-344 3-344 3-342 3-342 3-342 3-342 3-342 3-344 3-344	BD239B4 BD239B5 BD239B66 BD239C BD239C4 BD239C5 BD239C66 BD240 BD240-4 BD240-5	BD241B4 BD241B5 BD241B66 BD241C BD241C4 BD241C5 BD241C66 BD242 BD242-4 BD242-5	881 938 900 907 903 903 803 734 535	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-15 2-15 2-15	3-360 3-360 3-360 3-360 3-360 3-360 3-360 3-360
BD178-6 BD179 BD180 BD185 BD186 BD187 BD189 BD190 BD195 BD196	BD180-6 BD179 BD180 BD185 BD186 BD187 BD189 BD190 MJE3055 MJE2955	365 395 395 396 396 396 386 387	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-344 3-344 3-346 3-348 3-346 3-348 3-346 3-348 3-348 3-3132	BD240-66 BD240A4 BD240A4 BD240A5 BD240A66 BD240B BD240B4 BD240B5 BD240B66 BD240C	BD242-66 BD242A BD242A4 BD242A5 BD242A66 BD242B BD242B4 BD242B5 BD242B66 BD242C	538 537 538 5385 53055 63055 641 243 244 244	2-15 2-15 2-15 2-15 2-15 2-15 2-15 2-15	3-360 3-360 3-360 3-360 3-360 3-360 3-360 3-360
BD197 BD198 BD199 BD200 BD201 BD202 BD203 BD203 BD204 BD205 BD206	MJE2955 MJE3055 MJE2955 BD795 BD796 BD797 BD797 BD798 BD205	387 387 387 388 388 398 398 389 380	2-11 2-11 2-11 2-11 2-18 2-18 2-19 2-19 2-19	3-1132 3-1132 3-1132 3-1132 3-436 3-438 3-436 3-438 3-350 3-352	BD240C4 BD240C5 BD240C66 BD241A BD241A BD241B BD241C BD242 BD242B	BD242C4 BD242C5 BD242C66 BD241 BD241A BD241B BD241C BD242 BD242A BD242B	244A 8438 8448 833 835 835 836 798	2-15 2-15 2-15 2-15 2-15 2-15 2-15 2-15	3-360 3-360 3-362 3-362 3-362 3-362 3-362 3-362 3-362
BD207 BD208 BD220 BD221 BD222 BD223 BD223 BD224 BD225 BD226 BD227	BD208 BD537 BD533 BD535 BD538 BD534	963 638 639 649 649 649 649 649 649 649 649 649 64	2-11 2-11 2-18 2-18 2-18 2-18 2-18 2-18	3-350 3-352 3-418 3-418 3-418 3-418 3-418 3-418 3-332 3-334	BD242C BD243 BD243A BD243B BD243C BD244 BD244A BD244A BD244B BD244C BD249	BD242C BD243 BD243A BD243B BD243C BD244 BD2444 BD244B BD244C BD249	798 735 746 747 771 779 779 779 779 779 779 779	2-15 2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-362 3-366 3-366 3-366 3-366 3-366 3-366
BD228 BD229 BD230 BD231 BD232 BD233 BD234 BD235 BD236 BD237	BD232 BD233	101 101 101 101 101 102 102 103 103 103 103 103 103 103 103 103 103		3-332 3-334 3-332 3-334 3-354 3-356 3-358 3-356 3-358 3-356	BD249A BD249B BD249C BD250 BD250A BD250B BD250B BD250C BD253 BD253A BD253B	BD249A BD249B BD249C BD250 BD250A BD250B BD250C 2N6542 2N6542 2N6543	369 5200 534D 534D 537 397 397 398 399 300 300	2-16 2-16 2-16 2-16 2-16 2-16 2-16 2-16	3-253 3-253 3-253
BD238 BD239 BD239-4 BD239-5 BD239-66 BD239A BD239A4 BD239A4 BD239A5 BD239A66 BD239B	BD238 BD241 BD241-4 BD241-5 BD241-66 BD241A4 BD241A4 BD241A5 BD241A66 BD241B	213 213 213 213 214 214 214 214 214	2-9 2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-358 3-360 3-360 3-360 3-360 3-360 3-360 3-360 3-360	BD253C BD268 BD268A BD269A BD269A BD262A BD262A BD262B BD263A	BU326A BDW45 BDW46 BDW40 BDW41 BD678 BD680 BD682 BD677 BD679	902 1055 138 137 137 137 140 139 139	2-2 2-20 2-20 2-20 2-20 2-10 2-10 2-10 2	3-515 3-452 3-452 3-452 3-452 3-424 3-424 3-424 3-422 3-422

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beunitago) BOMBRBRBR 88080-XBOM

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BD263B BD266 BD266A BD266B BD267 BD267A BD267B BD271 BD272 BD273	BD681 BD898 BD900 BD902 BD897 BD899 BD901 BD533 BD534 BD535	24184 24186 2410 2410 24108 24108 2424	2-10 2-19 2-19 2-19 2-19 2-19 2-19 2-18 2-18 2-18	3-422 3-446 3-446 3-446 3-444 3-444 3-418 3-418 3-418	BD361A BD362 BD362A BD375 BD376 BD377 BD378 BD379 BD380 BD385	BD785 BD786 BD787 BD788 BD789 BD790	176 180-16 180-8 177-17 179-16 179-16 178-5	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-1096 3-1096 3-1096 3-428 3-428 3-428 3-432 3-432 3-376
BD274 BD275 BD276 BD278 BD278A BD278A BD279 BD280 BD291 BD292 BD293	BD536 BD537 BD538 MJE3055T ME3055T BD412 BD414 BD243 BD244 BD243A	242-86   242A 242A5 242A6 242B4 242B4 242B5 242B5 242C	2-18 2-18 2-18 2-11 2-11 2-14 2-14 2-18 2-18 2-18	3-418 3-418 3-418 3-1132 3-1132 3-384 3-366 3-366 3-366	BD385-1 BD385-2 BD385-5 BD385-8 BD386-8 BD386-1 BD386-1 BD386-5 BD386-8 BD387	BD385 BD386 BD386	160-6 179 186 186 187 187 190 190 182 186 186 186 186 186 186 186	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-376 3-376 3-376 3-376 3-380 3-380 3-380 3-380 3-376
BD294 BD295 BD296 BD301 BD302 BD303 BD304 BD304 BD301 BD302 BD303	BD244A BD243B BD244B BD533 BD534 BD535 BD536 BD795 BD796 BD797	242C4 242C5 341 341 341 341 341 342 342 342 342 342 342 342 342	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-366 3-366 3-418 3-418 3-418 3-418 3-436 3-436 3-436	BD387-1 BD387-2 BD387-5 BD387-8 BD388-8 BD388-1 BD388-2 BD388-5 BD388-8 BD389	BD387 BD387 BD387 BD387 BD388 BD388 BD388 BD388 BD388 BD388 BD388 BD389	E2066 E2465 E2466 796 797 738 206	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-376 3-376 3-376 3-376 3-380 3-380 3-380 3-380 3-376
BD304 BD306A BD306B BD307A BD307B BD311 BD312 BD313 BD314 BD315	BD798 BD785 BD785 BD787 BD787 2N3715 2N3791 2N3716 2N3792 BD368	242C 243A 243B 243C 243C 244A 244B 246B	2-19 2-10 2-10 2-10 2-10 2-3 2-3 2-3 2-3 2-3	3-438 3-428 3-428 3-428 3-370 3-370 3-26 3-56 3-373	BD389-1 BD389-2 BD389-5 BD389-8 BD390-1 BD390-1 BD390-2 BD390-5 BD390-8 BD410	BD390 BD390 BD390	207 208 507 507 535 536 536 536 536 536	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-376 3-376 3-376 3-376 3-380 3-380 3-380 3-380 3-380 3-354
BD316 BD329 BD337 BD338 BD330 BD331 BD332 BD333 BD334 BD335	BD369 MJE200 BDX33D BDX34D MJE210 BD897 BD898 BD899 BD900 BD901	7.49A 249C 250 250A 250A 250A 342 342	2-10 2-19 2-19 2-19 2-10 2-19 2-19 2-19 2-19 2-19	3-373 3-1096 3-458 3-458 3-1096 3-444 3-446 3-444 3-446 3-444	BD411 BD411-1 BD411-2 BD411-5 BD411-8 BD412-1 BD412-2 BD412-2 BD412-5 BD412-8	BD411 BD411 BD411 BD411 BD411 BD412 BD412 BD412 BD412 BD412 BD412	138 138 140 140 232 233 236 236 236 237	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-384 3-384 3-384 3-384 3-384 3-384 3-384 3-384 3-384
BD336 BD342 BD343 BD344 BD345 BD345 BD346 BD347 BD348 BD349 BD361	BD902 2N3055 MJE2955 BD138 BD137 BD798 BD797 BD140 BD139 MJE200	326A M46 M46 NA1 NA1 378 382 377	2-19 2-4 2-4 — 2-19 2-19 — — 2-10	3-446 3-6 3-6 3-334 3-332 3-438 3-436 3-334 3-332 3-1096	BD413 BD413-1 BD413-2 BD413-5 BD413-8 BD414-1 BD414-1 BD414-2 BD414-5 BD414-8	BD413 BD413 BD413 BD413 BD413 BD414 BD414 BD414 BD414 BD414	SATAS ANABE	2-14 2-14 2-14 2-14	3-388 3-388 3-388 3-388 3-388 3-388 3-388 3-388 3-388

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (hountings) 30M36333A 220R0-X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BD415 BD415-1 BD415-2 BD415-8 BD416-1 BD416-1 BD416-2 BD416-5 BD417 BD417-1	BD415 BD415 BD415 BD416 BD416 BD416 BD416 BD416 BD417	554 7785 876 876 876 876 677 677 677	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-392 3-392 3-392 3-392 3-396 3-396 3-396 3-396 3-392 3-392	BD509-1 BD509-5 BD510 BD510-5 BD515-5 BD515-5 BD516-1 BD516-1 BD516-5	BD509 BD509 BD510 BD510 BD515 BD515 BD515 BD516 BD516 BD516	810 548D 241 242 2414 242A 242B 2416	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-406 3-408 3-408 3-410 3-410 3-412 3-412 3-412
BD417-2 BD417-5 BD417-8 BD418-1 BD418-1 BD418-2 BD418-5 BD418-8 BD419-1	BD417 BD417 BD418 BD418 BD418 BD418 BD418 BD418 BD419	875A 579 6794 580 580 581 582 585 585 585 586	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-392 3-392 3-396 3-396 3-396 3-396 3-396 3-392 3-392	BD517 BD517-1 BD518 BD518-1 BD519-1 BD519-1 BD519-5 BD520 BD520-1 BD520-5	BD518 BD519 BD519	AMIC 533 536 536 537 538 538 2410 2410 2410	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-410 3-412 3-412 3-410 3-410 3-412 3-412 3-412
BD419-2 BD419-8 BD420 BD420-1 BD420-2 BD420-5 BD420-5 BD420-8 BD424 BD429 BD430	BD419 BD420 BD420 BD420 BD420 BD420 BD420 BD791 MJE200	Ades Tys Atys 868 Ades Ades Ades Ades Ades Ades Ades Ades	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-10 2-10 2-10	3-392 3-396 3-396 3-396 3-396 3-396 3-432 3-1096 3-1096	BD524 BD525 BD525-2 BD525-5 BD526-5 BD526-1 BD526-5 BD527 BD527-1 BD527-2	BD791 BD525 BD525 BD525 BD526 BD526 BD526 BD527 BD527 BD527	756 757 759 759 301 301 302 302 303 303	2-10 18 + 18 + 18 + 18 + 18 + 18 + 18 + 18 +	3-432 3-414 3-414 3-416 3-416 3-416 3-414 3-414 3-414
BD433 BD433-16 BD434 BD434-16 BD435 BD436 BD437 BD438 BD439 BD440	BD433 BD434 BD434 BD435 BD436	1965 196 197 197 198 190 190 191 193 193 193 193 193 193 193 193 193	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-400 3-403 3-403 3-403 3-400 3-403 3-400 3-403 3-400 3-403	BD527-5 BD528 BD528-1 BD528-5 BD529-1 BD529-1 BD529-2 BD529-5 BD530 BD530-1	BD528 BD529 BD529 BD529	568 006 007 568 768 768 768 860 963	2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-414 3-416 3-416 3-414 3-414 3-414 3-416 3-416
BD441 BD442 BD443 BD443A BD466A BD466B BD477A BD477B BD505 BD505-1	BD442 BD179 BD179	524 534 534 534 507 507 509	2-10 2-10 2-10 2-10 2-14 2-14 2-14 2-14 2-14 2-12 2-12	3-400 3-403 3-342 3-342 3-384 3-384 3-388 3-406 3-406	BD530-5 BD533 BD534 BD535 BD536 BD537 BD538 BD539 BD539A BD539B	BD536 BD537 BD538 BD243 BD243A	1440 1412 241 2413 2414 2418 2428 2428	2-12 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-416 3-418 3-418 3-418 3-418 3-418 3-366 3-366 3-366
BD505-5 BD506 BD506-5 BD507-1 BD507-1 BD507-5 BD508-1 BD508-5 BD508-5 BD509	BD506 BD506 BD507 BD507 BD507 BD508 BD508 BD508	906 908 910 776 778 778 778 778 779	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-406 3-408 3-406 3-406 3-406 3-408 3-408 3-408 3-408	BD539C BD540 BD540A BD540B BD540C BD543 BD543A BD543A BD543A BD5444 BD5444	BD805 BD807 BD809 BD806	197 100 100 100 100 100 100 100 100 100 10	2-18 2-18 2-18 2-18 2-18 2-19 2-19 2-20 2-19 2-19	3-366 3-366 3-366 3-366 3-440 3-440 3-442 3-442

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BD544B BD546D BD561 BD575 BD576 BD577 BD578 BD579 BD580 BD581	BD810 BD546D BD187 BD241 BD242 BD241A BD242A BD241B BD242B BD241C	900 600 012 016 316 316 316 316 316	2-20 ———————————————————————————————————	3-442 3-346 3-362 3-362 3-362 3-362 3-362 3-362 3-362 3-362	BD662K BD663 BD664 BD675 BD675A BD676A BD676A BD677 BD677A BD677A BD678	BD534 BD795 BD796 BD675 BD675A BD676A BD677A BD677A BD677A BD678	\$15 \$15 \$16 \$16 \$16 \$16 \$16 \$17	2-18 2-18 2-18 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-418 3-436 3-428 3-422 3-424 3-422 3-422 3-422
BD582 BD585 BD586 BD587 BD588 BD589 BD590 BD591 BD592 BD595	BD242C BD533 BD534 BD535 BD536 BD537 BD538 BD241C BD242C BD795	777 517 518 518 519 519 520 520 520	2-15 2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-15 2-15 2-15	3-362 3-418 3-418 3-418 3-418 3-418 3-418 3-362 3-362 3-436	BD678A BD679 BD679A BD680 BD680A BD681 BD682 BD692 BD695A BD696	BD678A BD679 BD679A BD680 BD680A BD681 BD682 BD895 BD895A BD896	617 617 618 618 618 618 618 618 618	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-424 3-422 3-422 3-424 3-424 3-444 3-444 3-446
BD596 BD597 BD598 BD599 BD600 BD601 BD601 BD602 BD605 BD606 BD607	BD796 BD797 BD798 BD799 BD800 BD801 BD802 BD805 BD806 BD806 BD807	127 1275 1276 1276 1277 1277 1277 1277	2-18 2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-19	3-438 3-438 3-436 3-438 3-436 3-438 3-440 3-442 3-440	BD696A BD697 BD697A BD698 BD6998A BD699A BD699A BD7000 BD700A BD701	BD896A BD897 BD897A BD898 BD898A BD899 BD899A BD900 BD900A BD901	619 629 620 620 620 620 6210 6210	2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-19	3-446 3-444 3-446 3-446 3-446 3-446
BD608 BD609 BD610 BD611 BD612 BD613 BD614 BD615 BD616 BD616	BD808 BD809 BD810 BD433 BD434 BD435 BD436 BD437 BD438 BD439	127 128 128 129 129 129 128 128 129 129	2-19 2-20 2-20 2-10 2-10 2-10 2-10 2-10 2-10	3-442 3-440 3-442 3-400 3-403 3-400 3-403 3-400 3-400	BD702 BD705 BD706 BD706 BD707 BD708 BD709 BD710 BD711 BD712 BD733	BD902 BD795 BD796 BD797 BD798 BD799 BD800 BD801 BD802 BD533	13.6 13.6 13.6 13.6 13.6 13.6 13.6 13.6	2-19 2-18 2-18 2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-18	3-446 3-438 3-438 3-438 3-438 3-438 3-438 3-418
BD618 BD619 BD620 BD633 BD634 BD635 BD636 BD637 BD638 BD638 BD643	BD440 BD441 BD442 BD241 BD242 BD241A BD242A BD241B BD242B BD895	OEI GO GO GO GO TEA EA F 7 A GEM	2-10 2-10 2-10 2-10 2-10 2-15 2-15 2-15 2-15 2-15 2-19	3-403 3-400 3-403 3-362 3-362 3-362 3-362 3-362 3-444	BD734 BD735 BD736 BD736 BD737 BD738 BD743 BD743A BD743A BD743C BD743D	BD534 BD533 BD534 BD533 BD534 BD805 BD807 BD809 C.M. MJE5180	641 179 179 172 172 173 173 173 173	2-18 2-18 2-18 2-18 2-18 2-19 2-19 2-20 2-18	3-418 3-418 3-418 3-418 3-440 3-440 3-1142
BD644 BD645 BD646 BD647 BD648 BD649 BD650 BD661 BD661K BD662	BD896 BD897 BD898 BD899 BD900 BD901 BD902 BD185 BD533 BD186	14.9C 14.4C 14.4C 14.4C 10.5 10.5 10.6 10.6 10.6 10.6 10.6	2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-10 2-10 2-18 2-10	3-446 3-444 3-446 3-446 3-446 3-446 3-346 3-348	BD744 BD744A BD744B BD744D BD775 BD776 BD777 BD778 BD779 BD779	BD806 BD808 BD810 MJE5170 BD775 BD776 BD777 BD778 BD779 BD780	105 106 107 107 107 107 108 108 108	2-19 2-19 2-20 	3-442 3-442 3-442 3-114: 3-426 3-426 3-426 3-426 3-426

<sup>\*</sup> Consult factory if a direct replacement is necessary. \*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (baunitred) 20M282724 22080-X20M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BD785 BD786 BD787 BD788 BD789 BD790 BD791 BD792 BD792 BD795 BD796	BD785 BD786 BD787 BD788 BD789 BD790 BD791 BD792 BD795 BD796	3713 3714 3789 3789 3783 3783 3784 3784 384	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-428 3-428 3-428 3-428 3-432 3-432 3-432 3-432 3-436 3-438	BD898 BD898A BD899 BD899A BD900 BD900A BD901 BD902 BD905 BD906	BD898 BD898A BD899 BD899A BD900 BD900A BD901 BD902 2N6486 2N6489	92C 141 1418 1416 142 142 1428 1428 1426	2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-19	3-446 3-444 3-444 3-446 3-446 3-245 3-245
BD797 BD798 BD799 BD800 BD801 BD801 BD802 BD805 BD806 BD807 BD808	BD797 BD798 BD799 BD800 BD801 BD802 BD805 BD806 BD807 BD808	XSAB WSB WAD WAQ WAQ WAG WAG WAG	2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-19	3-436 3-438 3-436 3-438 3-436 3-438 3-440 3-442 3-440 3-442	BD907 BD908 BD909 BD910 BD933 BD934 BD935 BD936 BD937 BD938	2N6487 2N6490 2N6488 2N6491 BD241 BD242 BD241A BD242A BD241B BD242B	1120 1127 1120 1120 1121 1122 1122 1122	2-20 2-20 2-20 2-20 2-15 2-15 2-15 2-15 2-15 2-15	3-245 3-245 3-245 3-245 3-362 3-362 3-362 3-362 3-362 3-362
BD809 BD810 BD813 BD814 BD815 BD816 BD816 BD817 BD818 BD810 BD825	BD809 BD810 BD385 BD386 BD387 BD388 BD389 BD390 BD810 BD385	3715 3716 3716 3781 3782 3782 3782 3783 3783 3783 3783 3783	2-20 2-20 2-13 2-13 2-14 2-14 2-14 2-14 2-20 2-13	3-440 3-442 3-376 3-380 3-376 3-380 3-376 3-380 3-442 3-376	BD939 BD941 BD942 BD942 BD940 BD943 BD944 BD945 BD946 BD947	BD241C TIP31D TIP32D TIP32D BD242C BD533 BD534 BD533 BD534 BD533	W45 W40 W40 W41 W42 W43 W45 W45 W45	2-15 2-17 2-17 2-17 2-15 2-18 2-18 2-18 2-18 2-18	3-362 3-1256 3-1256 3-362 3-418 3-418 3-418 3-418
BD826 BD827 BD828 BD829 BD839 BD830 BD830 BD833 BD834 BD835 BD836	BD386 BD387 BD388 BD389 C.M. BD390 BD785 BD786 BD787 BD788	XSAC XSA 120 121 121 121 125 125 126	2-13 2-14 2-14 2-14 2-14 2-10 2-10 2-10 2-10	3-380 3-376 3-380 3-380  3-380 3-428 3-428 3-428 3-428	BD948 BD949 BD955 BD955 BD956 BD950 BD951 BD952 BD953 BD954	BD534 BD535 TIP31D TIP31D TIP32D BD536 BD537 BD538 BD241C BD242C	10. W49. W42. W42. W42. 808. 808. 810. 810. 810. 811.	2-18 2-18 2-17 2-17 2-17 2-18 2-18 2-18 15 2-15	3-418 3-418 3-1247 3-1256 3-418 3-418 3-362 3-362
BD837 BD838 BD861 BD862 BD863 BD863 BD864 BD865 BD866 BD875 BD876	BD789 BD790 BD675 BD676 BD677 BD678 BD679 BD680 BD775 BD776	136 137 138 138 138 140 140 145 145 145 145 145 145 145 145 145 145	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-432 3-432 3-422 3-424 3-422 3-424 3-422 3-424 3-426	BD975 BD976 BD977 BD978 BD979 BD980 BD129 BD129A BD129B BD729B BD729C	BD775 BD776 BD777 BD778 BD779 BD780 TIP29 TIP30 TIP29B TIP29C	HT1017 HT1078 HT1020 HT1020 HT1020 NGA NGS NGS NGS NGS	2-10 2-10 2-10 2-10 2-10 2-10 2-17 2-17 2-17 2-17	3-426 3-426 3-426 3-426 3-426 3-125 <sup>2</sup> 3-125 <sup>2</sup> 3-125 <sup>2</sup>
BD877 BD878 BD879 BD880 BD895 BD895A BD896 BD896A BD897 BD897A	BD778 BD779 BD780 BD895 BD895A BD896 BD896A BD897	GSS3 ALSA ALSA SASA GASA GSS3 GSS3 GSS3 GSS3 GSS3 GS	2-10 2-10 2-10 2-10 2-19 2-19 2-19 2-19 2-19 2-19	3-426 3-426 3-426 3-426 3-444 3-446 3-446 3-444 3-444	BDT30 BDT30B BDT30C BDT31 A BDT31A BDT31B BDT31C BDT32 BDT32 BDT32A BDT32B	TIP30A TIP30B TIP30C TIP31 TIP31A TIP31B TIP31C TIP32 TIP32A TIP32B	90055 546 546 1395 1395 329 329 329 329 329	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1256 3-1256 3-1256

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

# INDEX-CROSS REFERENCE (Continued) (bsuning) 30/13/33/33 82083-33/34

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
BDT32C BDT41 BDT41A BDT41B BDT41C BDT41 BDT42A BDT42B BDT42C BDT60	TIP32C TIP41 TIP41A TIP41B TIP41C TIP42 TIP42A TIP42B TIP42C TIP125	698 A 968 Geed A 968 C 000 A 003 C 000 Geed Geed A 003 A 003	2-17 2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1256 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1281	BDW21A BDW21B BDW21C BDW22 BDW23 BDW23A BDW23B BDW23B BDW33C BDW24 BDW24A	2N3713 2N3714 2N37632 2N3789 BDX53 BDX53A BDX53A BDX53B BDX53C BDX54 BDX54	765 736 786 789 790 791 791 795 795	2-3 2-3 2-3 2-19 2-19 2-19 2-19 2-19 2-19	3-26 3-26 3-122 3-56 3-462 3-462 3-462 3-462 3-462
BDT60A BDT60B BDT60C BDT61 BDT61A BDT61B BDT61C BDT62C BDT63C BDT63C BDT64	TIP126 TIP127 BDX53D TIP120 TIP121 TIP122 BDX53D BDW48 BDW43 BDW44	8487 8490 8408 8481 241 241 2418 2418 2428	2-18	3-1281 3-1281 3-462 3-1281 3-1281 3-1281 3-462 3-452 3-452 3-452 3-452	BDW24B BDW24C BDW39 BDW40 BDW41 BDW42 BDW44 BDW45 BDW46 BDW47	BDX54B BDX54C BDW39 BDW40 BDW41 BDW42 BDW44 BDW45 BDW46 BDW47	7937 798 798 801 802 806 806 806 808	2-19 2-19 2-20 2-20 2-20 2-20 2-20 2-20 2-20 2-2	3-462 3-462 3-452 3-452 3-452 3-452 3-452 3-452 3-452
BDT64A BDT64B BDT64C BDT65 BDT65A BDT65B BDT65C BDT62 BDT62A BDT62B	BDW45 BDW46 BDW47 BDW40 BDW41 BDW42 BDW43 BDW45 BDW46 BDW47	24 IC 32D 32D 32D 347C 533 534 534 533	2-20 2-20 2-20 2-20 2-20 2-20 2-20 2-20	3-452 3-452 3-452 3-452 3-452 3-452 3-452 3-452 3-452 3-452 3-452	BDW51 BDW51A BDW51B BDW51C BDW52 BDW52A BDW52B BDW52C BDW53C BDW53C BDW53C	2N3715 2N3715 2N3716 2N5632 2N3791 2N3792 2N3792 2N3792 2N6229 BDX53C BDX53D	013 018 018 032 032 032 032 033 033 033 033	2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-19 2-19	3-26 3-26 3-26 3-122 3-56 3-56 3-122 3-462 3-462
BDT62C BDT63A BDT63A BDT63B BDT91 BDT92 BDT93 BDT94 BDV64C BDV65C	C.M. BDW40 BDW41 BDW42 BD807 BD808 BD809 BD810 MJH11017 MJH11018	834 31D 31D 34D 34D 336 537 531 531 241 242 242	2-20 2-20 2-19 2-19 2-20 2-20 2-20 2-23	3-452 3-452 3-452 3-452 3-440 3-442 3-440 3-442 3-448 3-448	BDW54C BDW54D BDW53 BDW53A BDW53B BDW53C BDW53D BDW54 BDW54 BDW54A BDW54A	BDX54C BDX54D TIP120 TIP120 TIP121 C.M. TIP125 TIP125 TIP126	886 387 383 399 390 786 786	2-19 2-19 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-462 3-462 3-128 3-128 3-128 3-128 3-128
BDV66C BDV66D BDV67C BDV67D BDV64 BDV64A BDV64B BDV65 BDV65A BDV65B	MJH11017 MJH11019 MJH11018 MJH11020 BDV64 BDV64A BDV64B BDV65 BDV65A BDV65B	776 776 778 779 780 23 30 288 288	2-15 2-15 2-15 2-15 2-15 2-15 2-15 2-15	3-448 3-448 3-448 3-448 3-448 3-448 3-448	BDW55 BDW56 BDW57 BDW58 BDW59 BDW60 BDW63 BDW63A BDW63A BDW63B	BD135 BD136 BD137 BD138 BD139 BD140 BDX53 BDX53A BDX53A BDX53B BDX53C	78.9 79.0 8.75 8.77 8.77 8.80 7.75 7.75	2-19 2-19 2-19 2-19 2-19	3-332 3-334 3-332 3-334 3-462 3-462 3-462 3-462
BDV91 BDV92 BDV93 BDV94 BDV95 BDV96 BDW22A BDW22A BDW22B BDW22C BDW21	TIP3055 TIP34B TIP34C TIP2955 TIP33B TIP33C 2N3789 2N3790 2N6229 2N3713	30A 30F 30F 31A 31A 31B 31C 32Z 32Z 32Z	2-15 2-15 2-15 2-15 2-15 2-3 2-3 2-3	3-1289 3-1260 3-1260 3-1289 3-1260 3-1260 3-56 3-56 3-56 3-56	BDW63D BDW64A BDW64A BDW64C BDW73D BDW74D BDW73 BDW73 BDW73 BDW738	BDX53D BDX54 BDX54A BDX54B BDX54C BDX33D BDX34D BD895 BD897 BD899	778 779 760 895 895 836 837	2-19 2-19 2-19 2-19 2-19 2-20 2-20 2-19 2-19 2-19	3-462 3-462 3-462 3-462 3-458 3-458 3-444 3-444

<sup>\*</sup> Consult factory if a direct replacement is necessary.
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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
BDW73C BDW74 BDW74A BDW74B BDW74C BDW83 BDW83A BDW83A BDW83A BDW83C BDW84	BD901 BD896 BD898 BD900 BD902 BDV65 BDV65 BDV65A BDV65B BDV65B	787 788 789 789 789 789 780 780	2-19 2-19 2-19 2-19 2-19 2-15 2-15 2-15 2-15 2-15	3-444 3-446 3-446 3-446 3-448 3-448 3-448 3-448 3-448	BDX71 BDX72 BDX73 BDX74 BDX75 BDX77 BDX78 BDX84 BDX84A BDX84A	2N6099 2N6101 2N6101 2N6103 2N6103 BD799 BD800 MJ2500 MJ2500 MJ2501	864 864 865 865 865 865 866 866	2-20 2-20 2-20 2-20 2-20 2-19 2-19 2-5 2-5 2-5	3-245 3-237 3-237 3-237 3-237 3-436 3-746 3-746 3-746
BDW84A BDW84B BDW84C BDW93 BDW93A BDW93B BDW93C BDW94 BDW94A BDW94B	BDV64 BDV64A BDV64B BDW39 BDW40 BDW41 BDW42 BDW44 BDW45 BDW46	750 751 751 751 751 752 752 752 753 757	2-15 2-15 2-15 2-20 2-20 2-20 2-20 2-20 2-20 2-20 2-2	3-448 3-448 3-448 ———————————————————————————————————	BDX84C BDX83 BDX83A BDX83B BDX83C BDX91 BDX92 BDX92 BDX93 BDX94 BDX95	MJ4032 MJ3000 MJ3000 MJ3001 MJ4035 2N3715 2N3791 2N3791 2N3792 2N3632	166 166 167 167 167 168 168	2-4 2-3 2-3 2-3 2-4 2-3 2-3 2-3 2-3 2-3	3-756 3-746 3-746 3-756 3-26 3-56 3-26 3-122
BDW94C BDX10 BDX10-4 BDX10-6 BDX10-7 BDX10-7 BDX10C BDX18 BDX33D BDX34D BDX35	BDW47 2N3055A 2N3055A 2N3055A 2N3055A 2N3055A 2N3055A MJ2955 BDX33D BDX34D TIP42C	757 787 790 790 791 781 606 205 807	2-20 2-4 2-4 2-4 2-4 2-4 2-20 2-20 2-18	3-6 3-6 3-6 3-6 3-6 3-458 3-458 3-1266	BDX96 BDV29 BDY34 BDY37 BDY80 BDY81 BDV82 BDY83 BDY93 BDY93/01	2N6229 2N5303 BD785 2N3773 BD533 BD535 BD536 BD536 BU326A BU326A	168 790 790 788 783 757 757 761 761	2-3 2-5 2-10 2-4 2-18 2-18 2-18 2-18 2-18 2-2 2-2	3-122 3-98 3-428 3-52 3-418 3-418 3-418 3-519 3-519
BDX36 BDX37 BDX33 BDX33A BDX33B BDX33C BDX344 BDX34A BDX34A BDX34B	TIP42D TIP42D BDX33 BDX33A BDX33B BDX33C BDX34 BDX34A BDX34A BDX34B BDX34C	426 EU 423 423 1716 7716 205 205 207	2-18 2-19 2-19 2-19 2-20 2-20 2-19 2-19 2-20 2-20 2-20	3-1266 3-1266 3-458 3-458 3-458 3-458 3-458 3-458 3-458 3-458 3-458	BDY94 BDY94/01 BDY96 BDY96-1 BDY96/01 BDY97 BDY97-1 BF380 BF380-5 BF381	BU326A BU326A BUS47 BUS47 BUS47 BUS47 BUS47 BUS47 MPSU10 MPSU10 MPSU10	790 781 787 787 787 787 787	2-2 2-2 2-3 2-3 2-3 2-3 2-3 2-12 2-12 2-	3-51! 3-54! 3-54! 3-54! 3-54! 3-54! 3-123 3-123
BDX35 BDX36 BDX37 BDX42 BDX43 BDX44 BDX45 BDX46 BDX47 BDX53D	MJE240 MJE240 MJE240 BD775 BD777 BD779 BD776 BD778 BD779 BD779 BDX53D	208 206 226A 226A 431 431 431 431 232 323 323P	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-1102 3-1102 3-1102 3-426 3-426 3-426 3-426 3-426 3-426 3-426 3-462	BF382 BF382-5 BF415 BF416 BF417 BF418 BF460-1 BF460-2 BF460-8 BF461-1	MPSU10 MPSU10 BF757 BF760 MJE340 BF761 BF460 BF460 BF460 BF460 BF460	758 759 759 759 759 760 760 760	2-12 2-12 2-13 2-13 2-9 2-13 2-13 2-13 2-13 2-13	3-123 3-123 4-479 4-483 3-110 4-483 3-467 3-467 3-467
BDX54D BDX53 BDX53A BDX53B BDX53C BDX54C BDX54A BDX54A BDX54A BDX54C BDX54C	BDX54D BDX53 BDX53A BDX53B BDX53C BDX54 BDX54A BDX54B BDX54B BDX54C 2N6099	226A 406 4. 407 6.	2-19 2-19 8 2-19	3-462 3-462 3-462 3-462 3-462 3-462 3-462 3-462 3-245	BF461-2 BF461-5 BF461-8 BF462-1 BF462-2 BF462-2 BF463-1 BF463-1 BF463-5 BF463-5	BF461 BF461 BF461 BF462 BF462 BF462 BF463 BF463 BF463 BF463	761 761 761 762 762 762 762 763	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-46; 3-46; 3-46; 3-46; 3-46; 3-47; 3-47; 3-47;

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BF464-1 BF464-2 BF464-5 BF464-8 BF465-1 BF465-2 BF465-5 BF465-8 BF466 BF466-1	BF464 BF464 BF464 BF465 BF465 BF465 BF465 BF466 BF466	9099 1916 1916 1916 1916 1916 1916 1916	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-471 3-471 3-471 3-471 3-471 3-471 3-471 3-475 3-475	BF787-1 BF788 BF788-1 BF788-5 BF789-1 BF789-11 BF789-5 BF790 BF790-1	BF787 BF788 BF788 BF788 BF789 BF789 BF789 BF789 BF789 BF790 BF790	108 888 868 900 500 700 700 800 800 800 800	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-487 3-487 3-487 3-487 3-487 3-487 3-487 3-487 3-487
BF466-2 BF466-8 BF467 BF467-1 BF467-2 BF467-8 BF468 BF468-1 BF468-2 BF468-5	BF466 BF467 BF467 BF467 BF467 BF468 BF468 BF468 BF468	603.2 2000 2001 3001 4035 776 7780 7780 6032	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-475 3-475 3-475 3-475 3-475 3-475 3-475 3-475 3-475 3-475	BF790-2 BF790-5 BF791 BF791-1 BF791-5 BF792-2 BF792-1 BF792-2 BF792-5 BF857	BF790 BF790 BF791 BF791 BF791 BF792 BF792 BF792 BF792 BF757	WEAR WEAR WAS WAA WAA WAA WAA WAA	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-487 3-487 3-487 3-487 3-487 3-487 3-487 3-487 3-479
BF468-8 BF469 BF470 BF471 BF472 BF615 BF616 BF617 BF618 BF715	BF468 BF787 BF790 BF788 BF791 BF757 BF760 BF758 BF761 BF787	2229 765 777 7772 765 536 536 536 536	2-14 2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-475 3-487 3-487 3-487 3-487 3-479 3-483 3-479 3-483 3-483	BF858 BF859 BF869 BF870 BF871 BF872 BU104P BU105 BU108 BU109P	BF757 BF758 BF787 BF790 BF788 BD791 BU406 BU205 BU208 BU407	M47 3055A 3055A 3056A 3056 2056 305A 230 M30 M30	2-13 2-13 2-13 2-13 2-13  2-2 2-2	3-479 3-479 3-487 3-487 3-487 3-432 3-518 3-490 3-495 3-518
BF716 BF717 BF718 BF757 BF757-1 BF757-2 BF757-5 BF757-8 BF758 BF758 BF758-5	BF790 BF758 BF761 BF757 BF757 BF757 BF757 BF757 BF758 BF758	828A 836N 847 847 847 840 840 840 840 840	2-13	3-487 3-479 3-483 3-479 3-479 3-479 3-479 3-479 3-479	BU124 BU126 BU126A BU134 BU137 BU157 BU204 BU205 BU205A BU207	BU426 BU126 MJ423 BUT16 BUT16 BU204 BU205 BU205 BU205 BU207	BUS45P 05 M	2-15 — 2-3 2-4 2-4 2-2 2-2 2-2 2-2	3-740 3-612 3-612 3-490 3-490 3-495
BF758-8 BF759 BF759-1 BF759-2 BF759-5 BF759-8 BF760-2 BF760-2 BF760-5 BF760-8	BF758 BF759 BF759 BF759 BF759 BF760 BF760 BF760 BF760	SU10 167 167 169 161 161 160 161 161	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-479 3-479 3-479 3-479 3-479 3-483 3-483 3-483 3-483 3-483	BU207A BU208 BU222 BU222A BU223A BU223A BU322 BU322A BU322A BU322A BU323P BU326	BU208 BU208 BU326A BU326A MJ431 BU323 BU323A BU323P	16249 1775 1779 1779 1779 1778	2-2 2-2 2-2 2-2 2-23 2-23 2-3 2-4 2-15 2-2	3-495 3-495 3-515 3-515 3-740 3-740 3-507 3-507 3-507 3-515
BF761 BF761-1 BF761-5 BF761-8 BF762-8 BF762-1 BF762-2 BF762-2 BF762-5 BF762-8 BF787	BF761 BF761 BF761 BF761 BF762 BF762 BF762 BF762 BF762 BF762 BF787	161 161 162 162 162 162 163 163 163	2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-483 3-483 3-483 3-483 3-483 3-483 3-483 3-483 3-483 3-483	BU326A BU326S BU406 BU406D BU406H BU407 BU407 BU426 BU426A BU426A	BU326A BU406 C.M. C.M. BU407 C.M. BU426A BU426A	BUS45P	2-19 — — — 2-19 — 2-15	3-515 3-515 3-518 3-518 3-518 3-518 3-518

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (hauntmod) 30M293333 22080-X30M

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BU500 BU522 BU522A BU522B BU522B BU806 BU807 BU808 BUR50 BUR50 BUR51 BUR52	BU500 BU522 BU522A BU522B BU806 BU807 BU208 BUS50 BUS51 BUS51 BUS52	ID11 1014 1018 1E5 1E5 1E5 1KQ 1KQ	2-3 2-19 2-19 2-19 2-19 2-19 2-2 2-29 2-6 2-6	3-524 3-526 3-526 3-526 3-534 3-534 3-495 3-576 3-578 3-578	BUV47 BUV47A BUV47B BUV48 BUV48A BUW24 BUW25 BUW26 BUW34 BUW35	BUS47P BUS47AP BUS47P BUS48P BUS48AP BU326A BU326A BU326A BUS47 BUS47	2585 3620 3621 2264 2264 2264 2265 22003 213003	2-15 2-15 2-15 2-15 2-15 2-3 2-3 2-3 2-3 2-3	3-548 3-548 3-555 3-569 3-515 3-515 3-515 3-548 3-548
BUS11 BUS12 BUS12A BUS13 BUS13A BUS14A BUS14A BUS36 BUS37 BUS47P	BUS47 BUS47A BUS48A BUS48A BUS98 BUS98A BUS36 BUS37 BUS47P	BUS46P	2-18 2-3 2-3 2-4 — 2-6 2-6 2-20 2-20 2-15	3-542 3-548 3-548 3-562 3-562 3-587 3-587 3-533 3-533 3-555	BUW36 BUW44 BUW45 BUW46 BUW72 BUW74 BUW75 BUW76 BUW77 BUW81	BUS47A BUS48 BUS48 BUS48A BUS47 BUS47 BUS47 BUS47 MJ10013	BUS46P	2-3 2-4 2-4 2-18 2-3 2-3 2-3 2-3 2-3 2-4	3-548 3-562 3-562 3-562 3-542 3-548 3-548 3-548 3-826
BUS46P BUS47 BUS47A BUS47AP BUS48 BUS48AP BUS48AP BUS50 BUS51 BUS52	BUS46P BUS47 BUS47A BUS47AP BUS48AP BUS48AP BUS48P BUS50 BUS51 BUS51	MI MC MC MC AND MC MC MC MC MC MC MC	2-18 2-3 2-3 2-15 2-4 2-15 2-15 2-15 2-29 2-6 2-6	3-542 3-548 3-548 3-562 3-569 3-569 3-576 3-578 3-578	BUW81A BUW84 BUW85 BUX14 BUX14CECCF BUX14CECCL BUX15 BUX15CECCF BUX15CECCL BUX16	MJ10014 MJE13003 MJE13003 BUS47 BUS47 BUS47A BUS47A BUS47A BUS47A	3208 326A 328A 328A 320C 320C 30C 30C 30C 30C 30C	2-4 2-9 2-9 2-3 2-3 2-3 2-3 2-3 2-3 2-2	3-826 3-1174 3-1174 3-548 3-548 3-548 3-548 3-548 3-548 3-253
BUS97 BUS97A BUS98 BUS98A BUT13 BUT14 BUT15 BUT16 BUT33 BUT34	BUS97 BUS97A BUS98 BUS98A BUT13 BUT14 BUT15 BUT16 BUT33 BUT34	103 103 107 107 108 103 1011 1011	2-5 2-6 2-6 2-6 2-5 2-5 2-5 2-4 2-6 2-6	3-580 3-587 3-587 3-587 3-594 3-600 3-606 3-612 3-618 3-624	BUX16A BUX16B BUX16C BUX17 BUX17A BUX17B BUX17C BUX18 BUX18B	2N6542 2N6542 2N6543 BUS48 BUS48 BUS48 BUS48 2N6544 2N6544 2N6545	904 205 205 206 206 201 201 2013 2013 2013 2013	2-2 2-2 2-2 2-4 2-4 2-4 2-3 2-3 2-3	3-253 3-253 3-253 3-562 3-562 3-562 3-259 3-259 3-259
BUT35 BUT36 BUT50P BUT51P BUT90 BUT91 BUT92 BUV10 BUV10N BUV11N	BUT35 BUT36 BUT50P BUT51P BUS50 BUS51 BUS52 BUV10 BUV10N BUV11N	284 284 284 284 284 284 284 284 284 284	2-6 2-5 2-15 2-15 2-29 2-6 2-6 2-5 2-5 2-5	3-630 3-636 3-642 3-644 3-576 3-578 3-578  3-645 3-651	BUX18C BUX39 BUX40 BUX41 BUX42 BUX42 BUX43 BUX44 BUX46 BUX46 BUX47	2N6545 BUX39 BUX40 BUX41 BUX42 2N6308 BUS47 BUS47A 2N6543 BUS47	265 0KJ 3KZ 3KG 0K4 0K4 0N2 0N2	2-3 2-5 2-5 2-4 2-4 2-3 2-3 2-3 2-3 2-3	3-259 3-678 3-681 3-687 3-690 3-693 3-548 3-548 3-253 3-548
BUV18 BUV19 BUV20 BUV21 BUV22 BUV23 BUV26 BUV27 BUV24 BUV25	BUS98	BUS50 BUS50	2-6 2-6	3-576 3-576 3-657 3-660 3-666 3-669 — 3-672 3-587	BUX47A BUX48A BUX48A BUX48S BUX666 BUX66A BUX66B BUX66C BUX67 BUX67A	BUS47A BUX48 BUX48A BUS48 2N6211 2N6212 2N6212 2N6213 2N3584 2N3584	BUS48 BUS48A	2-3 2-3 2-4 2-3 2-8 2-8 2-8 2-8 2-8 2-8	3-548 3-561 3-561 3-561 3-195 3-195 3-195 3-20 3-20

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beautines) BOMBRETER 22080-YEIGHT

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
BUX67B BUX67C BUX80 BUX81 BUX82 BUX83 BUX83 BUX84 BUX85 BUX86 BUX86 BUX87	2N3585 2N4240 BUS47 BUS47A BU326A BU326A MJE13005 MJE13003 MJE13003	9 AVS 9 AVS 4 CM 4 CM 9 ASS 8 BUS45P ASS 12-3 1	2-8 2-8 2-3 2-3 2-2 2-2 2-17 2-17 2-18 2-9	3-20 3-548 3-548 3-515 3-515 3-696 3-696 3-1174 3-1174	D41D11 841D13 941D14 941E1 941E5 941E7 941K1 941K2 941K3 941K4	D41D11 D41D13 D41D14 D41E1 D41E5 D41E7 D41K7 D41K2 D41K3 D41K4	500 522A 522A 502B 507 550 550 550	2-13 2-13 2-13 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-702 3-702 3-702 3-706 3-706 3-710 3-710 3-710 3-710
BUX97 BUX97A BUX97B BUX98 BUX98A BUX98A BUY99A BUY30 BUY49P BUY69A BUY69B	BU326A BU326A BU326A BUS98 BUS98A MJ410 MJ411 BUY49P BUS47A BUS47	\$47A \$46 \$48 \$48A \$47 \$47 \$47 \$47	2-2 2-2 2-2 2-6 2-6 2-6 2-2 2-10 2-3 2-3	3-515 3-515 3-515 3-587 3-587 3-738 3-738 3-738 3-548 3-548	D42C1 D42C2 D42C3 D42C4 D42C5 D42C6 D42C7 D42C8 D42C9 D43C1	S46P 22	MDS26 MDS26 MDS26 MDS27 MDS27 MDS27 MDS27 MDS27 MDS27 MDS27 MDS27	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-14	3-732 3-732 3-732 3-732 3-732 3-732 3-732 3-732 3-732
BUY69C BUY70A BUY70B BUY70C D40C1 D40C2 D40C4 D40C5 D40D1 D40D2	2N6306 BU326A BU326A BU326A D40C1 D40C2 D40C4 D40C5 D40D1 D40D2	E13800 E13003 647 647 847 647A 547A	2-3 2-3 2-3 2-13 2-13 2-13 2-13 2-13 2-1	3-218 3-515 3-515 3-515 3-699 3-699 3-699 3-702 3-702	D43C2 D43C3 D43C4 D43C5 D43C6 D43C7 D43C8 D43C8 D43C9 D44C1 D44C2	D44C1 D44C2	MDS76 MDS76 MDS77 MDS77 MDS77 MDS77 MDS77 MDS77	2-14 2-14 2-14 2-14 2-14 2-14 2-14 2-17 2-17	3-732 3-732 3-732 3-732 3-732 3-732 3-732 3-732 3-721 3-721
D40D3 D40D4 D40D5 D40D7 D40D8 D40D10 D40D11 D40D13 D40D14 D40D14	D40D4 D40D5 D40D7 D40D8 D40D10 D40D11 D40D13 D40D14 D40E1	D40D2 SARIO	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-702 3-702 3-702 3-702 3-702 3-702 3-702 3-702 3-702 3-706	D44C3 D44C4 D44C5 D44C6 D44C7 D44C8 D44C9 D44C10 D44C11 D44C12	D44C3 D44C4 D44C5 D44C6 D44C7 D44C8 D44C9 D44C10 D44C11 D44C12	597 597A 550 550 713 714 714 715 715 715	2-17 2-17 2-17 2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-721 3-721 3-721 3-721 3-721 3-721 3-721 3-721 3-721
D40E5 D40E7 D40K1 D40K2 D40K3 D40K4 D40N1 D40N1 D40N2 D40N3 D40N4	D40E5 D40E7 D40K1 D40K2 D40K3 D40K4 D40N1 D40N2 D40N3 D40N4	(40) (41) (42) (30) (54) (54) (54)	2-14 2-14 2-14 2-14 2-14 2-14 2-13 2-13 2-13 2-13 2-13	3-706 3-706 3-710 3-710 3-710 3-710 3-714 3-714 3-714 3-714	D44D1 D44D2 D44D3 D44D4 D44D5 D44D6 D44E1 D44E2 D44E3 D44H1	D44H1	2N6386 2N6386 2N6043 2N6043 2N6044 2N6044 2N6386 2N6387 2N6388	2-19 2-19 2-19 2-19 2-19 2-19 2-19 2-19	3-237 3-237 3-165 3-165 3-165 3-723 3-723 3-723 3-725
D40P1 D40P3 D40P5 D41D1 D41D2 D41D4 D41D5 D41D7 D41D8 D41D10	D40P1 D40P3 D40P5 D41D1 D41D2 D41D4 D41D5 D41D7 D41D8 D41D10	KABA B1 5211 5212 5212 5213 5213 5384	2-13 2-13 2-13 2-13 2-13 2-13	3-717 3-717 3-717 3-702 3-702 3-702 3-702 3-702 3-702 3-702 3-702	D44H2 D44H4 D44H5 D44H7 D44H10 D44H11 D44R1 D44R2 D44R3	D44H2 D44H4 D44H5 D44H7 D44H8 D44H10 D44H11	U8	2-19 2-19 2-19 2-19 2-19 2-20 2-20 2-17 2-17 2-17	3-725 3-725 3-725 3-725 3-725 3-725 3-1270 3-1270

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

# INDEX-CROSS REFERENCE (Continued) (beuning) 30/4383338 22080-X30/4

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
D44R4 D44R5 D44R6 D44TD3 D44TD5 D44TD5 D44TE3 D44TE4 D44TE5 D44VH1	00001 00001 00001 00001 00001 00001	TIP48 TIP47 TIP48 MJE13070 MJE13070 MJE13070 MJE13070 MJE13070 MJE13070	2-17 2-17 2-17 2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-19 2-20	3-1270 3-1270 3-1270 3-1202 3-1202 3-1202 3-1202 3-1202 3-727	DTS409 DTS410 DTS411 DTS413 DTS423 DTS423 DTS424 DTS425 DTS430 DTS431 DTS515	431 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6308 MJ410 MJ411 MJ413 MJ423 2N6308 2N6545 2N6307 MJ431 2N6306	2-3 2-2 2-2 2-3 2-3 2-3 2-4 2-3 2-3 2-3	3-218 3-738 3-740 3-740 3-218 3-259 3-218 3-740 3-218
D44VH4 D44VH7 D44VH10 D45C1 D45C2 D45C3 D45C4 D45C5 D45C6 D45C6	D44VH10 D45C1 D45C2 D45C3 D45C4 D45C5 D45C6	AM AM AM AM AM AM AM AM AM AM AM AM	2-20 2-20 2-20 2-17 2-17 2-17 2-17 2-17 2-18 2-18	3-727 3-727 3-727 3-721 3-721 3-721 3-721 3-721 3-721 3-721 3-721	DTS516 DTS517 DTS518 DTS519 DTS660 DTS663 DTS665 DTS701 DTS702 DTS712	10004 2 10005 2 10005 2 1002 2 1002 2 1005 2	2N6306 2N6306 2N6307 2N6308 2N6233 2N6235 2N6235 BU204 BU205 BU207	2-3 2-3 2-3 2-3 2-6 2-6 2-6 2-2 2-2 2-2	3-218 3-218 3-218 3-218 3-198 3-198 3-490 3-490 3-495
D45C8 D45C9 D45C10 D45C11 D45C12 D45E1 D45E2 D45E3 D45H1 D45H2	D45C8 D45C9 D45C10 D45C11 D45C12  D45H1 D45H2	TIP125 TIP125 TIP126	2-18 2-18 2-18 2-18 2-18 2-19 2-19 2-20 2-19 2-19	3-721 3-721 3-721 3-721 3-721 3-721 3-723 3-723 3-723 3-725 3-725	DTS714 DTS801 DTS802 DTS804 DTS812 DTS814 DTS1010 DTS1020 DTS4010 DTS4025	2308 2 5545 2 5307 2 530 2 525 2 5250 2 5251	BU208 BU205 BU207 BU208 BU208 BU208 2N6056 MJ3001 MJ3041 MJ3041	2-2 2-2 2-2 2-2 2-2 2-3 2-3 2-3 2-3	3-495 3-490 3-495 3-495 3-495 3-176 3-750
D45H4 D45H5 D45H7 D45H8 D45H9 D45H10 D45H11 D45H12 D45VH1	D45H5 D45H7 D45H8 D45H9 D45H10 D45H11 D45H12 D45VH1		2-19 2-19 2-19 2-19 2-19 2-20 2-20 2-20 2-20 2-20 2-20 2-20	3-725 3-725 3-725 3-725 3-725 3-725 3-725 3-725 3-725 3-727 3-727	DTS4026 DTS4039 DTS4040 DTS4041 DTS4045 DTS4059 DTS4060 DTS4061 DTS4065 DTS4066	23001 2 2578 2 2500 2 2501 2 2501 2 4:0 2 4:0 2 2004 2 2005 2 2005 2	MJ10012 MJ10000 MJ10000 MJ10000 MJ10000 MJ10001 MJ10001 MJ10001 MJ10000	2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5	3-822 3-790 3-790 3-790 3-790 3-790 3-790 3-790
D45VH7 D45VH10 D56W1 D56W2 D56W3 D56W4 D64VE3 D64VE4 D64VE5 D54VP3	- D45VH7 - D45VH10 - E653 - T52	BU208 BU208 BU207 BU207 MJ13080 MJ13080 MJ13080	2-2 2-3	3-727 3-727 3-495 3-495 3-495 3-978 3-978 3-978 3-978 3-984	DTS4067 DTS4074 DTS4075 FT47 FT48 FT49 FT50 FT317 FT317A FT317B	C FT317 000 FT317A 0000 FT317B 0000	MJ10000 MJ10004 MJ10004 TIP47 TIP48 TIP49 TIP50 MJE15028	2-5 2-5 2-5 2-17 2-17 2-17 2-17 2-18 2-18 2-18	3-790 3-802 3-802 3-127/ 3-127/ 3-127/ 3-120/ 3-120/
D64VP4 D64VP5 D64VS3 D64VS4 D64VS5 DTS310 DTS311 DTS401 DTS402 DTS402	22 22 23 23 24 25 25 25 25 25 25 25 25 25 25 25 25 25	MJ13090 MJ13090 MJ13100 MJ13100 MJ13100 2N6306 2N6306 2N3902 2N3902 2N3902 2N6308	2-4 2-5 2-5	3-984 3-984 3-990 3-990 3-218 3-218 3-60 3-60 3-218	FT401 FT402 FT410 FT411 FT4113 FT417, FT417A FT417B FT423 FT430	FT417B 0000	MJ423	2-2 2-2 2-2 2-3 2-18 2-18 2-18 2-3 2-3	3-60 3-60 3-738 3-738 3-740 3-740 3-218

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beautino) 30/43/33/33 220/30/33/33/33

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
FT431 FT2955 FT3055 GE5061 GE5061 GE5062 GE6061 GE6062 GE6021	8308 1 2 410 2 411 4 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	MJ431 MJE2955T MJ3055T MJ10000 MJ10000 MJ10001 MJ10015 MJ10015 MJ10015 MJ10004	2-3 2-11 2-11 2-5 2-5 2-5 2-6 2-6 2-6 2-5	3-740 3-6 3-6 3-790 3-790 3-790 3-832 3-832 3-832 3-796	IR4059 IR4060 IR4061 IR4065 IR4502 IR5000 IR5001 IR5002 IR5060 IR5061	### 2	MJ10000 MJ10001 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000	2-5 2-5 2-5 2-5 2-6 2-5 2-5 2-5 2-5	3-790 3-790 3-790 3-790 3-758 3-790 3-790 3-790 3-790
GE6252 GE6253 IR401 IR402 IR403 IR409 IR410 IR411 IR413 IR423	2006 3306 3207 3233 3235 3235 2235 2006 2007	MJ10004 MJ10005 2N3902 2N3902 2N6308 2N6308 MJ410 MJ411 MJ413 MJ423	2-5 2-5 2-2 2-2 2-3 2-3 2-2 2-2 2-3 2-3	3-796 3-802 3-60 3-60 3-218 3-218 3-738 3-738 3-740 3-740	IR5062 IR5252 IR5261 IR6000 IR6001 IR6002 IR6060 IR6061 IR6062 IR6251	And see the things the see the see that	MJ10001 MJ10003 MJ10002 MJ10004 MJ10004 MJ10005 MJ10004 MJ10005 MJ10006		3-790 3-796 3-796 3-796 3-796 3-802 3-796 2-802 3-808
IR424 IR425 IR430 IR431 IR515 IR516 IR517 IR518 IR519 IR640	203 205 207 208 207 208 208 308 304 304 304	2N6308 2N6545 2N6307 MJ431 2N6250 2N6250 2N6251 2N6546 2N6547 MJ3000	2-3 2-4 2-3 2-3 2-4 2-4 2-4 2-4 2-3	3-218 3-259 3-218 3-740 3-201 3-201 3-201 3-263 3-263	IR6252 IR6302 KDT410 KDT411 KDT413 KDT423 KDT423 KDT431 KDT515	22 22 23 25 25 25 26 26 27 26 27 27 28 28 28 28 28 28 28 28 28 28 28 28 28	MJ10007 2N5630 MJ410 MJ411 MJ413 MJ423 2N6307 MJ431 2N6306 2N6306	2-3 2-4 2-2 2-2 2-3 2-3 2-3 2-3 2-3 2-3	3-808 3-118 3-738 3-738 3-740 3-740 3-218 3-740 3-218 3-218
IR641 IR642 IR645 IR646 IR647 IR660 IR663 IR665 IR701 IR801	1001	MJ3001 2N6578 MJ2500 MJ2501 2N6052 MJ410 MJ423 MJ12003 BU204 BU205	2-3 2-4 2-3 2-3 2-4 2-2 2-3 2-30 2-2 2-2	3-978 3-746 3-746 3-172 3-738 3-740 3-944 3-490 3-490	KDT517 KDT518 KDT519 KP3946 KP3948 MDS20 MDS21 MDS21 MDS26 MDS27 MDS60	MDS20 MDS21 MDS26 MDS27 MDS60	2N6306 2N6307 2N6308 2N6274 2N6274 8H	2-3 2-3 2-3 2-6 2-6 2-13 2-13 2-14 2-14 2-13	3-218 3-218 3-218 3-205 3-205 3-729 3-729 3-732 3-732 3-734
IR802 IR900 IR901 IR1000 IR1001 IR1010 IR1020 IR2500 IR2501 IR3000	10000 2 10004 2 10004 2 17 10004 2 18 18 18 18 18 18 18 18 18 18 18 18 18	MJ802 MJ900 MJ901 MJ1000 MJ1001 2N6056 MJ3001 MJ2500 MJ2501 MJ3000	2-6 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-742 3-744 3-744 3-744 3-744 3-176  3-746 3-746	MDS73 MDS74 MDS75 MDS76 MDS77 MDS1678 MJ105 MJ205 MJ400 MJ410	MDS76 MDS77 BU205 BU205 MJ400 MJ410	MDS77 MJE172 MJE253 MDS27 2N3739	2-14 2-10 2-10 2-14 2-14 2-14 2-2 2-2 2-8 2-2	3-732 3-1092 3-1102 3-732 3-732 3-736 3-490 3-37 3-738
IR3001 IR3771 IR3772 IR3773 IR4039 IR4040 IR4041 IR4045 IR4050 IR4055	907 7 1902 7 190	MJ3001 2N3771 2N3772 2N3773 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000 MJ10000	2-3 2-5 2-5 2-4 2-5 2-5 2-5 2-5 2-5 2-5 2-5	3-48 3-48 3-52 3-790 3-790 3-790 3-790 3-790 3-790	MJ411 MJ413 MJ423 MJ424 MJ425 MJ431 MJ450 MJ480 MJ480 MJ490	MJ411 MJ413 MJ423 MJ424 MJ425 MJ431	2N6308 2N6545 2N4398 2N3713 2N3713 2N3789	2-2 2-3 2-3 2-3 2-3 2-3 2-8 2-3 2-3 2-3	3-738 3-740 3-740 3-218 3-259 3-740 3-68 3-26 3-26 3-56

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (bearings) 30M393339 32090-X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
MJ491 MJ701 MJ702 MJ704 MJ721 MJ723 MJ802 MJ804 MJ900 MJ901	MJ802 MJ900 MJ901	2N3789 MJ12002 MJ12002 MJ12002 MJ12002 MJ12002 MJ12004	2-3 2-2 2-2 2-2 2-2 2-2 2-6 2-2 2-3 2-3	3-56 3-939 3-939 3-939 3-939 3-742 3-946 3-744 3-744	MJ4361 MJ4380 MJ4381 MJ4400 MJ4401 MJ4502 MJ4645 MJ4646 MJ4647 MJ6502	MJ4502 MJ4645 MJ4646 MJ4647 MJ6502	MJE13003 MJE13004 MJE13005 MJE13004 MJE13005	2-7	3-1174 3-1180 3-1180 3-1180 3-758 3-760 3-760 3-760 3-762
MJ920 MJ921 MJ1000 MJ1001 MJ1200 MJ1220 MJ2249 MJ2250 MJ2251 MJ2252	MJ1000 MJ1001 MJ2250	(2) 2N6298 (2) 2N6299 (2) 2N6300 (2) 2N6301 2N3766 2N3767 2N3738* 2N3739*	2-8 2-8 2-3 2-3 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-176 3-176 3-735 3-735 3-176 3-176 3-44 3-44 3-37 3-37	MJ6503 MJ6700 MJ8100 MJ8500 MJ8501 MJ8502 MJ8503 MJ8504 MJ8505 MJ1000	MJ6503 MJ6700 MJ8100 MJ8500 MJ8501 MJ8502 MJ8502 MJ8503 MJ8504 MJ8505 MJ1000	17 1030 17 1031 17 1032 17 1033 17 2003 17 2004 17 2010 17 2010	2-2 2-2 2-4 2-4	3-762 3-768 3-770 3-772 3-772 3-778 3-784 3-784 3-790
MJ2253 MJ2254 MJ2267 MJ2268 MJ2300 MJ2305 MJ2500 MJ2501 MJ2801 MJ2801 MJ2802	MJ2500 MJ2501 MJ2801	2N3740* 2N3741* 2N6594 MJ2955 MJE270 MJE271 2N6569 2N5881*	2-8 2-8 2-4 2-4 2-9 2-9 2-3 2-3 2-4 2-4	3-41 3-41 3-52 3-6 3-1106 3-1106 3-746 3-746 3-280 3-143	MJ10001 MJ10002 MJ10003 MJ10004 MJ10005 MJ10006 MJ10007 MJ10009 MJ10009 MJ10011	MJ10001 MJ10002 MJ10003 MJ10004 MJ10005 MJ10006 MJ10007 MJ10008 MJ10009 MJ10011	1 20 1 20 1 20 1 20 1 20 1 20 1 20 20 20 20 20 20 20 20 20 20 20 20 20	2-5 2-3 2-3 2-5 2-5 2-3 2-3 2-3 2-5 2-3	3-790 3-796 3-796 3-802 3-802 3-808 3-808 3-814 3-814 3-820
MJ2840 MJ2841 MJ2901 MJ2940 MJ2955 MJ2955A MJ3000 MJ3001 MJ3029 MJ3030	MJ2955 MJ2955A MJ3000 MJ3001 MJ3029 MJ3030		2-3 2-3 2-4 2-3 2-4 2-3 2-3 2-2 2-2	3-140 3-140 3-52 3-140 3-6 3-6 3-748 3-748	MJ10012 MJ10013 MJ10014 MJ10015 MJ10016 MJ10020 MJ10021 MJ10022 MJ10023 MJ10024	MJ10012 MJ10013 MJ10014 MJ10015 MJ10016 MJ10020 MJ10021 MJ10022 MJ10023 MJ10024	113091 113100 11330 11333 11333 11333 11333	2-4 2-4 2-6 2-6	3-820 3-820 3-833 3-833 3-833 3-833 3-844 3-844 3-844
MJ3040 MJ3041 MJ3042 MJ3055 MJ3055A MJ3237 MJ3238 MJ3247 MJ3248 MJ3248 MJ4030	MJ3040 MJ3041 MJ3042 MJ3055 MJ3055A MJ3237 MJ3238 MJ3247 MJ3248 MJ4030	11 11 11 11 11 11 12 22 28 28		3-750 3-750 3-750 3-6 3-6 3-752 3-752 3-752 3-752 3-756	MJ10025 MJ10041 MJ10042 MJ10044 MJ10045 MJ10047 MJ10048 MJ10050 MJ10051 MJ10052	MJ10025 MJ10041 MJ10042 MJ10044 MJ10045 MJ10047 MJ10048 MJ10050 MJ10051 MJ10052	14003 114003 115001 115002 115003 115003	2-21	3-849 3-854 3-869 3-854 3-869 3-883 3-891 3-891
MJ4031 MJ4032 MJ4033 MJ4034 MJ4035 MJ4237 MJ4238 MJ4247 MJ4248 MJ4248 MJ4360	MJ4031 MJ4032 MJ4033 MJ4034 MJ4035 MJ4237 MJ4238 MJ4247 MJ4248	21 22 22 22 23 2105	2-3 2-3	3-756 3-756 3-756 3-756 3-756 3-752 3-752 3-752 3-752 3-1174	MJ10100 MJ10101 MJ10102 MJ10200 MJ10201 MJ10202 MJ11011 MJ11012 MJ11013 MJ11014	MJ10100 MJ10101 MJ10102 MJ10200 MJ10201 MJ10202 MJ11011 MJ11012 MJ11013 MJ11014	15015 115016 115022 115023 115024 115025 115026 115027	2-25 2-25 2-25 2-25 2-5	3-899 3-907 3-907 3-915 3-923 3-931 3-931 3-931 3-931

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (boundary) 30M3R3R3R 280R0-X3dM

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
MJ11015 MJ11016 MJ11017 MJ11018 MJ11020 MJ11020 MJ1021 MJ1022 MJ1028 MJ11029	MJ1101608131	M Md Nd Nd Nd	M 2-6	3-931 3-933 3-933 3-933 3-933 3-933 3-933 3-937 3-937	MJ16002A MJ16004 MJ16006 MJ16006A MJ16008 MJ16010 MJ16010A MJ16012 MJ16014 MJ16016		1802	2-4 M 2-5	3-1038 3-1030 3-1049 3-1053 3-1060 3-1060 3-1076 3-1076
MJ11030 MJ11031 MJ11032 MJ11033 MJ12002 MJ12003 MJ12004 MJ12005 MJ12010 MJ12020	MJ11030 MJ11031 MJ11032 MJ11033 MJ12002 MJ12003 MJ12004 MJ12005 MJ12010 MJ12020	18500 18501 18502 18503 18504 18506	2-6 2-6 2-6 2-2 2-30 2-2 2-2	3-937 3-937 3-937 3-937 3-939 3-944 3-946 3-952 3-954 3-956	MJ16018 MJE29 MJE29A MJE29B MJE29C MJE30 MJE30A MJE30A MJE30C MJE31	MJ16018_3MS_2MS_2MS_2MS_3MS_3MS_3MS_3MS_3MS_3MS_3MS_3MS_3MS_3	TIP29* TIP29A* TIP29B* TIP29C* TIP30A* TIP30B* TIP30C* TIP31*	2-17 2-17 2-17 2-17	3-1084 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254
MJ12021 MJ12022 MJ13010 MJ13014 MJ13015 MJ13018 MJ13019 MJ13070 MJ13071 MJ13080	MJ12021 MJ12022 MJ13014 MJ13015 MJ13070 MJ13071 MJ13080	10009	2-4 2-4 2-3 2-4 2-5 2-5 2-5	3-956 3-956 3-263 3-966 3-966 3-996 3-972 3-972 3-978	MJE31A B MJE31B MJE31C MJE32C MJE32A MJE32B MJE32C MJE33 MJE33A MJE33B	3740* 3741* 3741* 2955 8594 2955 E270 4 E271 2586	TIP41	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-18 2-18 2-18	3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1266 3-1266
MJ13081 MJ13090 MJ13091 MJ13100 MJ13101 MJ13330 MJ13331 MJ13332 MJ13333 MJ13334	MJ13081 MJ13090 MJ13091 MJ13100 MJ13101 MJ13330 MJ13331 MJ13332 MJ13333 MJ13334	10012 10014 10014 10016 10016 10021 10021 10022 10024	2-4 2-4 2-5 2-5 2-5 2-5 2-5 2-5 2-5	3-978 3-984 3-984 3-990 3-990 3-996 3-996 3-1002 3-1002 3-1002	MJE33C MJE34A MJE34A MJE34B MJE34C MJE41 MJE41A MJE41B MJE41C MJE42	5877 5878 5876	TIP41A 000E TIP41B 1000 TIP41C 000E	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1260 3-1260 3-1260 3-1260 3-1260 3-1260 3-1260 3-1260
MJ13335 MJ14000 MJ14001 MJ14002 MJ14003 MJ15001 MJ15002 MJ15003 MJ15004 MJ15011	MJ13335 MJ14000 MJ14001 MJ14002 MJ14003 MJ15001 MJ15002 MJ15003 MJ15004 MJ15011	110044 110045 110047 110069 110050	2-6 2-6 2-6 2-6 2-6 2-4 2-4	3-1002 3-1008 3-1008 3-1008 3-1008 3-1012 3-1012 3-1015 3-1015 3-1018	MJE42A MJE42B MJE42C MJE47 MJE48 MJE51 MJE51T MJE52 MJE52T		TIP42B TIP42C TIP47 TIP48 TIP49 2N6497	2-18 2-18 2-18 2-17 2-17 2-17 2-18 2-18 2-18 2-18	3-1266 3-1266 3-1270 3-1270 3-1270 3-249 3-249 3-249 3-249
MJ15012 MJ15015 MJ15016 MJ15022 MJ15023 MJ15024 MJ15025 MJ15026 MJ15027 MJ16002	MJ15012 MJ15015 MJ15016 MJ15022 MJ15023 MJ15024 MJ15025 MJ15026 MJ15027 MJ16002	110207 110202 111011 111012 111013	2-4 2-4 2-4 2-4 2-5 2-5	3-1018 3-9 3-9 3-1020 3-1023 3-1020 3-1023 3-1026 3-1026 3-1030	MJE53 MJE53T MJE101 MJE102 MJE103 MJE104 MJE105 MJE105K MJE170 MJE171	MJE105 MJE170 MJE17100073	2N6499 2N5974 2N5975 2N5976 2N5976	2-18 2-18 2-11 2-11 2-11 2-11 2-11 2-18 2-9 2-10	3-249 3-249 3-151 3-151 3-151 3-150 3-1090 3-1092 3-1092

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#### INDEX-CROSS REFERENCE (Continued) (beautiful (Continued))

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
MJE172 MJE180 MJE181 MJE182 MJE200 MJE201 MJE202 MJE203 MJE203 MJE204 MJE204	MJE172 MJE180 MJE181 MJE182 MJE200	2N5977 2N5978 2N5978 2N5978 2N5979	2-11 2-11 2-11	3-1092 3-1092 3-1092 3-1092 3-1096 3-154 3-154 3-154 3-154 3-1100	MJE700T MJE701 MJE701T MJE702 MJE702T MJE703T MJE703T MJE710 MJE711 MJE711	MJE700T MJE701T MJE701T MJE702T MJE702T MJE703T MJE710 MJE711 MJE711	JE2801   M JE2801T   M	2-18 ×1 2-9 2-9	3-1120 3-1120 3-1120 3-1120 3-1120 3-1120 3-1120
MJE205K MJE210 MJE220 MJE221 MJE222 MJE223 MJE224 MJE225 MJE230 MJE231	202 202 202 203 203 203 203 203 203 203	TIP41A  MJE181* MJE181* MJE181* MJE182* MJE182* MJE182* MJE171* MJE171*	2-18 2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-1266 3-1096 3-1092 3-1092 3-1092 3-1092 3-1092 3-1092 3-1092 3-1092	MJE720 MJE721 MJE722 MJE800 MJE800T MJE801T MJE801T MJE802 MJE802T MJE803	MJE720 MJE721 MJE722 MJE800 MJE800 MJE8011 MJE8011 MJE802 MJE802 MJE803	163066   MA   MA   MA   MA   MA   MA   MA	2-9 2-9 2-10 2-18 2-10	3-1120 3-1120 3-1120 3-1120 3-1120 3-1120 3-1120
MJE232 MJE233 MJE234 MJE235 MJE240 MJE241 MJE242 MJE243 MJE243 MJE244 MJE250	MJE240 MJE241 MJE242 MJE243 MJE244 MJE250	E6043 E6043 E6045 E6045	2-10 2-10 2-10 2-10 2-10 2-10 2-10 2-10	3-1092 3-1092 3-1092 3-1092 3-1102 3-1102 3-1102 3-1102 3-1102 3-1102	MJE803T 01- MJE1090 01- MJE1091 01- MJE1092 01- MJE1093 01- MJE1100 01- MJE1101 01- MJE1102 01- MJE1103 01- MJE1290 01-	MJE1093 MJE1100 MJE1101 MJE1102 MJE1103	JE3311 JE3312 M	2-11 2-11 M 2-11	3-1120 3-1124 3-1124 3-1124 3-1124 3-1124 3-1124 3-1124 3-1124
MJE251 MJE252 MJE253 MJE254 MJE254 MJE270 MJE340 MJE340 MJE340K MJE341 MJE341K	MJE251 MJE252 MJE253 MJE254 MJE270 MJE271 MJE340	E 2003 E 12007 E 13003 E 13004 E 13004 E 13006 E 13006	2-10 2-10 2-9 2-9 2-9 2-17 2-9	3-1102 3-1102 3-1102 3-1106 3-1106 3-1108 3-1270 3-1110 3-1270	MJE1291 MJE1660 MJE1661 MJE2010 MJE2011 MJE2020 MJE2021 MJE2055 MJE2055 MJE2090 MJE2090	MJE1291 844 MJE1660 MJE1661	TIP42 TIP42A TIP41A TIP41A MJE200 MJE3055 TIP125	2-11 2-18 2-18 2-18 2-18 2-10	3-1126 3-1126 3-1266 3-1266 3-1266 3-1266 3-1266 3-1130 3-1130
MJE344 MJE344K MJE345 MJE350 MJE370 MJE370K MJE371K MJE371K MJE482 MJE483	MJE344 MJE350 MJE370 MJE371	TIP47 MJE3439 TIP32	2-10 M	3-1110 3-1270 3-1136 3-1112 3-1114 3-1260 3-1116 3-1260 3-90 3-90	MJE2091 MJE2092 MJE2093 MJE2100 MJE2101 MJE2102 MJE2103 MJE2150 MJE2160 MJE2360	A06** 806* 93* A83* 863*	TIP125 TIP126 TIP126 TIP120 TIP120 TIP121 TIP121 MJE210 TIP48 MJE2360T	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-128 3-128 3-128 3-128 3-128 3-128 3-128 3-129 3-127 3-1120
MJE484 MJE488 MJE492 MJE493 MJE494 MJE520 MJE520K MJE521K MJE521K MJE700	MJE520 MJE521 MJE700	2N5192 2N5191 2N5193 2N5194 2N5195 TIP31	2-10 2-10 2-10 2-10 2-9 2-17 2-10 2-17	3-90 3-90 3-94 3-94 3-94 3-1118 3-1256 3-1120	MJE2360T MJE2361 MJE2361 MJE2370 MJE2370 MJE2371 MJE2480 MJE2481 MJE2482 MJE2483 MJE2483 MJE2490	MJE2360T MJE2361T	MJE2361T TIP32 TIP32A TIP31 TIP31A 2N6121 2N6122 TIP32	2-17 2-17 2-17 2-15 2-15 2-17 2-17 2-18 2-18 2-18	3-1126 3-1126 3-1256 3-1256 3-1256 3-1256 3-185 3-185 3-185

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (bsunitation) 30/42/R3434 220/R3-730/M

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
MJE2491 MJE2520 MJE2521 MJE2522 MJE2523 MJE2801 MJE2801K MJE2801T MJE2901 MJE2901K	MJE2801 MJE2801T MJE2901	TIP31 TIP31A TIP31A TIP31A TIP31A MJE2801T	2-11 2-11 2-11 2-11	3-1256 3-1256 3-1256 3-1256 3-1256 3-1130 3-1130 3-1130 3-1130 3-1130	MJE5730 MJE5731 MJE5732 MJE5740 MJE5740 MJE5741 MJE5742 MJE5850 MJE5851 MJE5852 MJE5960	MJE5730 MJE5731 MJE5732 MJE5740 MJE5741 MJE5742 MJE5850 MJE5851 MJE5852	2773 0873L 1873L 0023L 2023L 2023L	2-17 2-17 2-17 2-19 2-19 2-19 2-19 2-19 2-19 2-20	3-1146 3-1146 3-1150 3-1150 3-1154 3-1154 3-1154 3-245
MJE2901T MJE2955 MJE2955K MJE2955T MJE3055 MJE3055K MJE3055T MJE3300 MJE3301 MJE3302	MJE2901T MJE2955 MJE2955T MJE3055 MJE3055T MJE3300 MJE3301 MJE3302	MJE2955T MJE3055T	2-11 2-11 2-11 2-11 2-11 2-11 2-11 2-10 2-10	3-1130 3-1132 3-1132 3-1132 3-1132 3-1132 3-1132 3-1134 3-1134 3-1134	MJE5974 MJE5975 MJE5976 MJE5977 MJE5978 MJE5979 MJE5980 MJE5981 MJE5982 MJE5983	M1A JE181* E181* E182* E182* E182* JE171*	TIP42 TIP42A TIP42B TIP41 TIP41A TIP41B 2N6489 2N6490 2N6491 2N6486	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-20 2-20 2-20 2-20	3-1266 3-1266 3-1266 3-1266 3-1266 3-245 3-245 3-245 3-245
MJE3310 MJE3311 MJE3312 MJE3370 MJE3371 MJE3439 MJE3440 MJE3520 MJE3521 MJE3738	MJE3310 MJE3311 MJE3312 MJE3439 MJE3440	MJE370 2N5193 MJE520 M2N5190		3-1134 3-1134 3-1134 3-1114 3-94 3-1136 3-1136 3-1118 3-90 3-1270	MJE5984 MJE5985 MJE6040 MJE6041 MJE6042 MJE6043 MJE6044 MJE6045 MJE8500 MJE8501	MJE6045 MJE8500	2N6487 2N6488	2-20 2-20 2-11 2-11 2-11 2-11 2-11 2-17 2-17	3-245 3-245 3-165 3-165 3-165 3-165 3-165 3-1160 3-1160
MJE3739 MJE4340 MJE4341 MJE4342 MJE4343 MJE4350 MJE4351 MJE4351 MJE4352 MJE4353 MJE4918	MJE4340 MJE4341 MJE4342 MJE4343 MJE4351 MJE4351 MJE4352 MJE4353		2-17 2-15 2-15 2-15 2-15 2-15 2-15 2-15 2-15	3-1270 3-1138 3-1138 3-1138 3-1138 3-1138 3-1138 3-1138 3-1138 3-1138 3-1254	MJE8502 MJE8503 MJE12007 MJE13002 MJE13003 MJE13004 MJE13005 MJE13006 MJE13007 MJE13008	MJE12007 MJE13002 MJE13003 MJE13004 MJE13005 MJE13006 MJE13007	E341 1	2-18 2-18 2-17 2-9 2-9 2-18 2-18 2-19 2-19 2-20	3-1160 3-1170 3-1170 3-1170 3-1180 3-1180 3-1180 3-1180 3-1190
MJE4919 MJE4920 MJE4921 MJE4922 MJE4923 MJE5170 MJE5171 MJE5172 MJE5180 MJE5181	MJE5170 MJE5171 MJE5172 MJE5180 MJE51810	TIP30A TIP30B TIP29 TIP29A TIP29B	2-17 2-17 2-17 2-17 2-17 2-18 2-18 2-18 2-18	3-1254 3-1254 3-1254 3-1254 3-1254 3-1142 3-1142 3-1142 3-1142 3-1142	MJE13009 MJE13070 MJE13071 MJE15028 MJE15029 MJE15030 MJE15031 MJE16002 MJE16004 MJH6282	MJE13009 MJE13070 MJE13071 MJE15028 MJE15029 MJE15030 MJE15031 MJE16002 MJE16004 MJH6282**	16360 M 16370 TI 16371 TI	2-18 2-18 2-19	3-1194 3-1200 3-1200 3-1208 3-1208 3-1208 3-1212 3-1212
MJE5182 MJE5190 MJE5191 MJE5192 MJE5193 MJE5194 MJE5195 MJE5655 MJE5656 MJE5657	MJE5182 T18853L 2020 1951 A153 1913 S151 2020		2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1142 3-185 3-185 3-185 3-185 3-185 3-185 3-1270 3-1270 3-1270	MJH6283 MJH6284 MJH6285 MJH6286 MJH6287 MJH11017 MJH11018 MJH11019 MJH11020 MJH11021	MJH6283** MJH6284** MJH6285** MJH6286** MJH6287** MJH11018** MJH11019** MJH11020** MJH11021**	20 20 21 21 21 21 21 21 21 21 21 21 21 21	2-15	NLE 486 NLE 486 NLE 483 NLE 484 NLE 520 NLE 520 NLE 521 NLE 521 NLE 521

<sup>\*</sup> Consult factory if a direct replacement is necessary. \*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beunitros) 30M3R333A 220R3-X3QM1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
MJH11022 MJH12004 MJH13090 MJH13091 MJH16002A MJH16002A MJH16004 MJH16006 MJH16006A MJH16008	MJH11022** MJH12094 MJH13090 MJH13091 MJH16002A MJH16002A MJH16006 MJH16006A MJH16008	ML ML 2N	2-15 ————————————————————————————————————	3-946 3-984 3-984 3-1030 3-1038 3-1030 3-1045 3-1053 3-1045	NSDU01A NSDU05 NSDU06 NSDU07 NSDU45 NSDU51 NSDU51A NSDU55 NSDU56 NSDU57	122 2 2 1 2 1 2 1 2 2 2 2 2 2 2 2 2 2 2	MPSU01 MPSU05 MPSU06 MPSU07 MPSU45 MPSU51 MPSU51A MPSU55 MPSU56 MPSU57	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-1220 3-1228 3-1228 3-1230 3-124 3-1230 3-1230 3-1230
MJH16010 MJH16010A MJH16012 MJH16018 MPC900 MPC1000 MPSU01 MPSU01A	MJH16010 MJH16010A MJH16012 MJH16018 MPSU01 MPSU01A	MC1563 & 2N6050 MC1726 & 2N6077	2-15 2-15 2-15 2-30 2-4 2-8 2-12 2-12	3-1060 3-1068 3-1060 3-1084 3-172 3-180 3-1220 3-1220	NSE170 NSE171 NSE180 NSE181 NSP41 NSP41A NSP41B NSP41C NSP42 NSP42	120 21 121 21 123 22 22 23 31 24 31 24 32 23 32 3	MJE170 MJE171 MJE180 MJE181 TIP41 TIP41A TIP41B TIP41C TIP42 TIP42A	2-9 2-10 2-9 2-10 2-18 2-18 2-18 2-18 2-18 2-18	3-1092 3-1092 3-1092 3-1092 3-1266 3-1266 3-1266 3-1266 3-1266
MPSU02 MPSU03 MPSU04 MPSU05 MPSU06 MPSU07 MPSU10 MPSU11 MPSU12 MPSU31	MPSU02 MPSU03 MPSU04 MPSU05 MPSU06 MPSU07 MPSU10	MPSU10 MPSU45	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-1222 3-1224 3-1224 3-1228 3-1228 3-1230 3-1232 3-1232 3-1238 3-1235	NSP42B NSP42C NSP105 NSP205 NSP370 NSP371 NSP520 NSP521 NSP575 NSP576	21A 22 530557 24 30 22 30 22 30 22 30 22 30 22 3121 22 3121 22	TIP42B TIP42C TIP42A TIP41A TIP32 TIP32 TIP31 TIP31 TIP29A TIP30A	2-18 2-18 2-18 2-18 2-17 2-17 2-17 2-17 2-17 2-17	3-126 3-126 3-126 3-125 3-125 3-125 3-125 3-125
MPSU45 MPSU47 MPSU51 MPSU51A MPSU52 MPSU55 MPSU56 MPSU57 MPSU60 MPSU95	MPSU45  MPSU51 MPSU51A MPSU52 MPSU55 MPSU56 MPSU57 MPSU60 MPSU95	MPSU31	2-12 2-12 2-12 2-12 2-12 2-12 2-12 2-12	3-1238 3-1241 3-1241 3-1243 3-1243 3-1245 3-1245 3-1247 3-1249 3-1251	NSP577 NSP578 NSP579 NSP580 NSP581 NSP582 NSP585 NSP586 NSP586 NSP587 NSP588	1123 22 1124 22 1125 22 1126 22 1238 22 113 114 118 22 118	TIP29A TIP30A TIP29B TIP30B TIP29C TIP30C TIP29A TIP30A TIP29A TIP30A	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-125 3-125 3-125 3-125 3-125 3-125 3-125 3-125
NSD102 NSD103 NSD104 NSD105 NSD106 NSD131 NSD132 NSD132 NSD133 NSD134 NSD135	1668 2-4 1663 2-4 1663 2-4 1690 2-2 1690 2-4 169	2N6551 2N6551 2N6552 2N6552 2N6553 2N6557 2N6557 2N6557 2N6558 2N6558	2-13 2-13 2-14 2-14 2-14 2-13 2-13 2-13 2-13 2-13	3-270 3-270 3-270 3-270 3-270 3-277 3-277 3-277 3-277 3-277	NSP589 NSP590 NSP595 NSP596 NSP597 NSP598 NSP699 NSP600 NSP695 NSP695A	HISS 22 2 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1	TIP29B TIP30B TIP31A TIP31A TIP31A TIP32A TIP32B TIP32B TIP120 TIP100	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-125/ 3-125/ 3-125/ 3-125/ 3-125/ 3-125/ 3-125/ 3-128/ 3-127/
NSD151 NSD152 NSD202 NSD203 NSD204 NSD205 NSD206 NSD3439 NSD3440 NSD3440 NSDU01	100 24 37 24 37 24 38 27 32 24 32 32 32 32	2N6554 2N6555 2N6555	2-14 2-14 2-13 2-13 2-14 2-14 2-14 2-9 2-9 2-12	3-267 3-267 3-274 3-274 3-274 3-274 3-274 3-1136 3-1136 3-1220	NSP696 NSP696A NSP697 NSP697A NSP698 NSP698A NSP699 NSP699A NSP700	2058 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP100 TIP125 TIP105 TIP121 TIP101 TIP126	2-18 2-19 2-18 2-19 2-18 2-19 2-18 2-19 2-18 2-19	3-128 3-127- 3-128 3-127- 3-128 3-127- 3-128 3-127-

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

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#### INDEX-CROSS REFERENCE (Continued) (beuntined) 32M3R3333 22CR3 (20M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
NSP701 NSP702 NSP2010 NSP2011 NSP2021 NSP2090 NSP2091 NSP2092 NSP2093 NSP2093 NSP2000	Supplement of the supplement o	TIP122 TIP127 TIP42 TIP42A TIP41A TIP125 TIP125 TIP126 TIP126 TIP120	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1281 3-1281 3-1266 3-1266 3-1266 3-1281 3-1281 3-1281 3-1281 3-1281	PMD13K-40 PMD13K-60 PMD13K-80 PMD13K-100 PMD16K-40 PMD16K-60 PMD16K-100 PMD17K-40 PMD17K-60		MJ900 MJ900 MJ901 2N6052 2N6282 2N6282 2N6283 2N6283 2N6284 2N6285 2N6284	2-3 2-3 2-4 2-5 2-5 2-5 2-5 2-5	3-744 3-744 3-744 3-172 3-209 3-209 3-209 3-209 3-209 3-209
NSP2101 NSP2102 NSP2103 NSP2370 NSP2480 NSP2481 NSP2490 NSP2491 NSP2520 NSP2555	E170 2-2 E171 2-2 E181 2-2 A1 2-2 A1 2-2 A1 2-2 B2	TIP120 TIP121 TIP121 TIP32 TIP31 TIP31A TIP32 TIP32A TIP32A TIP31 MJE2955T	2-18 2-18 2-18 2-17 2-17 2-17 2-17 2-17 2-17 2-11	3-1281 3-1281 3-1281 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1132	PMD17K-80 PMD17K-100 PMD20K-120 PMD25K-120 PMD1600K PMD1601K PMD1602K PMD1603K PMD1700K PMD1701K	2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-2-	2N6578 2N6578 2N6282 2N6282 2N6282 2N6283	2-5 2-4 2-4 2-5 2-5 2-5 2-5 2-5	3-209 3-209 3-284 3-284 3-209 3-209 3-209 3-209 3-209 3-209
NSP3054 NSP3055 NSP4918 NSP4919 NSP4920 NSP4921 NSP4922 NSP4922 NSP4923 NSP5190 NSP5191	A2B 2A	TIP31A MJE3055T TIP30 TIP30A TIP30B TIP29 TIP29A TIP29B 2N6121 2N6122	2-17 2-11 2-17 2-17 2-17 2-17 2-17 2-17	3-1256 3-1132 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-185 3-185	PMD1702K PMD1703K RCA1801 RCA1804 RCA1805 RCA1806 RCA1609 RCA1C03 RCA1C04 RCA1C05	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.	2N6287 2N5878 MJ15022 MJ15024 MJ15003 MJ15024 MJE15028 MJE15029	2-5 2-5 2-3 2-4 2-5 2-5 2-5 2-19 2-19 2-19	3-209 3-209 3-140 3-1020 3-1015 3-1020 3-1208 3-1208
NSP5192 NSP5193 NSP5194 NSP5195 NSP5974 NSP5975 NSP5976 NSP5976 NSP5977 NSP5978 NSP5979	29A 2-1 20A 2-1 20A 2-1 20B 2-	2N6123 2N6124 2N6125 2N6126 TIP42 TIP42A TIP42B TIP41 TIP41A	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-185 3-185 3-185 3-185 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266	RCA1C06 RCA1C07 RCA1C08 RCA1C09 RCA1C10 RCA1C11 RCA1C12 RCA1C13 RCA1C14 RCA1C15	66 66 66 66 66 66 66 66 66 66 66 66 66	2N6133 MJE3055T MJE3055T MJE3055T 2N6292 2N6107 MJE15028 MJE15029 2N6290 2N6388	2-11 2-11 2-11 2-19 2-19 2-19 2-19 2-19	3-1132 3-1132 3-1132 3-182 3-1208 3-1208 3-182 3-182 3-237
NSP5980 NSP5981 NSP5982 NSP5983 NSP5983 NSP5985 PM26K380 PM27K380 PMD10K-40 PMD10K-60	288 2288 22881 22881 22882 22882 22882 22882 22882 22882 228828 2288282 22882 22882 22882 22882 22882 22882 22882 22882 22882 228828	2N6489 2N6490 2N6491 2N6486 2N6487 2N6488 MJ13015 2N6543 2N6057 2N6057	2-20 2-20 2-20 2-20 2-20 2-20 2-4 2-2 2-4 2-2	3-245 3-245 3-245 3-245 3-245 3-245 3-966 3-253 3-172 3-172	RCA1C16 RCA1E02 RCA1E03 RCA29 RCA29A RCA29A RCA29B RCA29C RCA30 RCA30A RCA30B	7551 2- 2-2552 2-25557 2-25557 2-25557 2-25558 2-25558 2-25558 2-25558 2-25558 2-25558 2-25558 2-25558 2-25558 2-2	2N6668 2N3583 2N6420 TIP29 TIP29A TIP29B TIP29C TIP30 TIP30A TIP30B	2-20 2-8 2-8 2-17 2-17 2-17 2-17 2-17 2-17	3-295 3-20 3-20 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254
PMD10K-80 PMD10K-100 PMD11K-40 PMD11K-60 PMD11K-80 PMD11K-100 PMD12K-40 PMD12K-60 PMD12K-80 PMD12K-100	125 2-1 106 2-1 109 2-1 105 2-1 105 2-1 105 2-1 107 2-1 107 2-1 107 2-1 108 2-1 108 2-1 109 2-	2N6058 2N6059 2N6050 2N6050 2N6051 2N6052 MJ1000 MJ1000 MJ1001 2N6059	2-4 2-4 2-4 2-4 2-4 2-5 2-5 2-5 2-5	3-172 3-172 3-172 3-172 3-172 3-172 3-172 3-744 3-744 3-744 3-744	RCA30C RCA31 RCA31A RCA31A RCA31C RCA32C RCA32A RCA32A RCA32B RCA32C RCA41	5649   2-1   5648   2-1   5648   2-1   5654   2-1   5656   2-1   5656   2-1   56440   2-1   2-	TIP30C TIP31 TIP31A TIP31B TIP31C TIP32 TIP32A TIP32B TIP32C TIP41	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-1254 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1266

<sup>\*</sup> Consult factory if a direct replacement is necessary. \*\* To be introduced. Contact factory for Data Sheet.

### INDEX-CROSS REFERENCE (Continued) (beunitmod) 30M3R373R 220R0-X30M1

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Sheet Page
RCA41A RCA41B RCA41C RCA42 RCA42A RCA42A RCA42B RCA42C RCA120 RCA121 RCA121	5337 5336 5336 5337 5337 3719 3720 536 538 538 539 539	TIP41A TIP41B TIP41C TIP42 TIP42A TIP42B TIP42C TIP120 TIP121 TIP121	2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1281 3-1281 3-1281	RCP133D RCP135 RCP135B RCP137 RCP137B RCS579 RCS617 RCS617 RCS618 SDM6000 SDM6001	8008 8008 8008 8008 8008 8008 8008 800	2N6559 2N6553 2N6557 2N6553 2N6557 2N6306 2N5882 2N5880 MJ10012 MJ10012	2-13 2-14 2-13 2-14 2-13 2-3 2-4 2-4 2-3 2-3	3-277 3-270 3-277 3-270 3-277 3-218 3-143 3-143 3-826
RCA125 RCA126 RCA410 RCA411 RCA413 RCA423 RCA423 RCA423 RCA1000 RCA1001 RCA3054	8192 2 3367 2 3368 2 8303 3 8173 8 817 2 8187 2 2367 2 3367 2 3367 2	TIP125 TIP126 MJ410 MJ411 MJ413 MJ423 MJ431 MJ1000 MJ1001 2N6122	2-18 2-18 2-2 2-2 2-3 2-3 2-3 2-3 2-3 2-18	3-1281 3-1281 3-738 3-738 3-740 3-740 3-740 3-744 3-744 3-185	SDM6002 SDM6003 SDM20301 SDM20302 SDM20303 SDM20314 SDM20311 SDM20312 SDM20313 SDM20314	6307 6307 6307 6307 6308 6308 6308 6308 6308	MJ10012 MJ10012 MJ4033 MJ4033 MJ4034 MJ4035 MJ4033 MJ4033 MJ4034 MJ4035	2-3 2-3 2-4 2-4 2-4 2-4 2-4 2-4 2-4 2-4 2-4	3-826 3-826 3-756 3-756 3-756 3-756 3-756 3-756
RCA3055 RCA3441 RCA6263 RCA8203 RCA8203A RCA8203A RCA8203B RCA8350 RCA8350A RCA8350A RCA8350B RCA8350B	\$336 \$337 \$337 \$337 \$337 \$337 \$337 \$337	2N6487 MJE15030 MJE15030 2N6666 2N6667 2N6668 2N6648 2N6649 2N6650 MJ10002	2-20 2-19 2-19 2-19 2-19 2-20 2-3 2-3 2-3 2-3	3-245 3-1208 3-1208 3-295 3-295 3-295 3-233 3-233 3-233 3-796	SDM20321 SDM20322 SDM20323 SDM20324 SDM21301 SDM21302 SDM21303 SDM21304 SDM21311 SDM21311	8308 5627 5628 5640 5643 5643 6643 5338 5338	MJ4033 MJ4033 MJ4034 MJ4035 MJ4030 MJ4030 MJ4031 MJ4032 MJ4030 MJ4030	2-4 2-4 2-4 2-4 2-4 2-4 2-4 2-4 2-4	3-756 3-756 3-756 3-756 3-756 3-756 3-756 3-756
RCA8766A RCA8766B RCA8766C RCA8766D RCA8766D RCA87667 RCA8767A RCA8767A RCA8767B RCA9113 RCA9113A	75885 2 41A 2 41A 2 41A 2 42A 2 42A 2 5337 2 5337 3	MJ10002 MJ10003 MJ10003 MJ10003 MJ10003 2N6546 2N6547 2N6547 2N6547 2N6546 2N6547	2-3 2-3 2-3 2-3 2-3 2-4 2-4 2-4 2-4 2-4	3-796 3-796 3-796 3-796 3-796 3-263 3-263 3-263 3-263 3-263 3-263	SDM21313 SDM21314 SDN1010 SDN1020 SDN4040 SDN4045 SDN6000 SDN6001 SDN6002 SDN6000	85/45 666	MJ4031 MJ4032 2N6056 MJ3001 MJ10000 MJ10000 MJ10000 MJ10000 MJ10001 MJ10000	2-4 2-4 2-3 2-3 2-5 2-5 2-5 2-5 2-5 2-5	3-756 3-756 3-176  3-790 3-790 3-790 3-790
RCA9113B RCP111A RCP111B RCP111C RCP111D RCP113A RCP113B RCP113C RCP113D RCP115	533.9 533.7 533.7 533.7 533.7 533.7 533.7 533.7 533.7 533.7 533.7	2N6547 2N6557 2N6557 2N6559 2N6559 2N6557 2N6557 2N6557 2N6558 2N6559 2N6591	2-4 2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-263 3-277 3-277 3-277 3-277 3-277 3-277 3-277 3-277 3-287	SDN6061 SDN6062 SDN6251 SDN6253 SDT7A01 SDT7A02 SDT7A03 SDT7A08 SDT7A09	8235 6186 6180 6100 6100 6190 6190 8100 8100 8190	MJ10000 MJ10000 MJ10002 MJ10002 MJ10003 2N5428 2N5428 2N5428 2N5427 2N5427	2-5 2-5 2-3 2-3 2-8 2-8 2-8 2-8 2-8	3-790 3-790 3-796 3-796 3-114 3-114 3-114 3-114
RCP115B RCP117 RCP117B RCP131A RCP131B RCP131C RCP131D RCP133A RCP133B RCP133C	3796 3787 5050 5050 3766 3767 3767 3767 3767 3767 3767 376	2N6557 2N6591 2N6557 2N6592 2N6593 2N6558 2N6559 2N6592 2N6593 2N6558	2-13 2-13 2-13 2-13 2-13 2-13 2-13 2-13	3-277 3-287 3-277 3-287 3-287 3-277 3-277 3-287 3-287 3-277	SDT401 SDT402 SDT410 SDT411 SDT413 SDT423 SDT424 SDT425 SDT425 SDT430 SDT431	8192 2 5347 2 5347 2 5347 2 5347 2 5347 2 5347 2 5347 2	2N6543 2N6543 MJ410 MJ411 MJ413 MJ423 2N6308 2N6545 2N6307 MJ431	2-2 2-2 2-2 2-2 2-3 2-3 2-3 2-3 2-3 2-3	3-253 3-253 3-738 3-738 3-740 3-218 3-259 3-218 3-740

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

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Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
SDT520 SDT521 SDT522 SDT525 SDT526 SDT526 SDT527 SDT530 SDT531 SDT531 SDT532 SDT535	8559 8553 8553 8557 8506 8306 116012 116012	2N6306 2N6306 2N6306 2N6306 2N6306 2N6306 2N6306 2N6306 2N6306 2N6306	2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218	SDT3422 SDT3423 SDT3424 SDT3425 SDT3426 SDT3426 SDT3428 SDT3501 SDT3502 SDT3503	MIA 2 2 2 4 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N5337 2N5336 2N5338 2N5337 2N5337 2N5336 2N5338 2N3719 2N3720 2N6303	2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-27 — 2-7	3-102 3-102 3-102 3-102 3-102 3-102 3-102 3-32 3-32 3-32
SDT536 SDT537 SDT540 SDT541 SDT542 SDT545 SDT546 SDT546 SDT547 SDT550 SDT551	10012 10072 4033 4004 4005 4023 4036 4036 4036	2N6307 2N6307 2N6307 2N6307 2N6307 2N6307 2N6308 2N6308 2N6308 2N6308 2N6308	2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-3	3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218	SDT3504 SDT3505 SDT3506 SDT3507 SDT3508 SDT3775 SDT3776 SDT3777 SDT3778 SDT3778 SDT4451	125 2 1726 2 1410 2 1413 4 123 2 14001 2 14001 2 152 2 2	2N6192 2N3867 2N3868 2N6303 2N6193 2N3867 2N3868 2N6303 2N3867 2N5337	2-7 2-27 2-27 2-7 2-7 2-27 2-27 2-7 2-27 2-7	3-192 3-32 3-32 3-32 3-192 3-32 3-32 3-32 3-102
SDT552 SDT707 SDT1050 SDT1051 SDT1052 SDT1053 SDT1054 SDT1055 SDT1056 SDT1056 SDT1057	4033 4024 4036 4030 4030 4031 4031 4030 4030	2N6308 2N5427 2N5838 2N5840 2N6543 2N6543 2N6543 2N5838 2N3902 2N6545	2-3 2-8 2-2 2-2 2-2 2-2 2-2 2-2 2-2 2-3	3-218 3-114 3-138 3-138 3-253 3-253 3-253 3-138 3-60 3-259	SDT4452 SDT4453 SDT4454 SDT4455 SDT4456 SDT4483 SDT4901 SDT4902 SDT4903 SDT4904	8487 2 615030 2 615030 2 6067 2 6068 2 6068 2 6068 2 6068 2 6068 2	2N5336 2N5337 2N5336 2N5337 2N5337 2N5337 2N5337 2N3583 2N6233 2N6234 2N3585	2-7 2-7 2-7 2-7 2-7 2-7 2-8 2-8 2-8 2-8	3-102 3-102 3-102 3-102 3-102 3-102 3-108 3-198 3-20
SDT1058 SDT1059 SDT1060 SDT1061 SDT1063 SDT1063 SDT1064 SDT1301 SDT1302 SDT1303	4931 4932 3031 3031 10000 10000 10000 10001	2N6545 2N6545 2N5838 2N3902 2N6545 2N6545 2N6545 2N6235 2N6235 2N6235	2-3 2-3 2-2 2-2 2-3 2-3 2-8 2-8 2-8	3-259 3-259 3-137 3-60 3-259 3-259 3-259 3-198 3-198 3-198	SDT4905 SDT5101 SDT5102 SDT5103 SDT5111 SDT5112 SDT5113 SDT5501 SDT5501 SDT5502 SDT5503	10002 10003 10003 10003 10003 10003 10047 1047 1047 1047 1047	2N3585 TIP41A TIP41A TIP41A TIP42A TIP42A TIP42A 2N5337 2N5337 2N5337	2-8 2-18 2-18 2-18 2-18 2-18 2-18 2-7 2-7 2-7	3-20 3-126 3-126 3-126 3-126 3-126 3-126 3-102 3-102
SDT1304 SDT3125 SDT3126 SDT3321 SDT3322 SDT3322 SDT3323 SDT3324 SDT3325 SDT3325 SDT3327	16000 16000 16002 16003 16003 1428 1428 1428 1427	2N6235 2N6186 2N6186 MJ8100 MJ8100 2N6190 2N6192 MJ8100 MJ8100 2N6190	2-8 — — 2-7 2-7 2-7 2-7 2-7 2-7 2-7	3-198 3-189 3-189 3-770 3-770 3-192 3-770 3-770 3-192	SDT5504 SDT5506 SDT5507 SDT5508 SDT5509 SDT5511 SDT5512 SDT5513 SDT5514 SDT5901	\$547	2N5339 2N5337 2N5337 2N5336 2N5336 2N5337 2N5337 2N5337 2N5337 2N5339 2N3766	2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7 2-7	3-229 3-102 3-102 3-102 3-102 3-102 3-102 3-44
SDT3328 SDT3401 SDT3402 SDT3403 SDT3404 SDT3405 SDT3406 SDT3406 SDT3407 SDT3408 SDT3421	\$54.2 410 413 413 413 413 423 5307 633	2N6192 2N5347 2N5347 2N5347 2N5349 2N5347 2N5347 2N5347 2N5347 2N5347 2N5349 2N5337	2-7 2-28 2-28 2-28 2-28 2-28 2-28 2-28 2	3-192 3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-102	SDT5902 SDT5903 SDT5904 SDT5905 SDT5906 SDT5907 SDT5908 SDT5909 SDT5910 SDT5911	8557 2 2 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	2N3766 2N3767 2N5050 2N5050 2N3766 2N3766 2N3767 2N5050 2N5050 2N5050	2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-44 3-48 3-88 3-88 3-44 3-44 3-88 3-88

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

### INDEX-CROSS REFERENCE (Continued) (beunitmod) BOMBREER 22080-XEIGHT

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
SDT5912 SDT5913 SDT5914 SDT5951 SDT5952 SDT5952 SDT5954 SDT5955 SDT5956 SDT6308	13030 2 13090 2 13091 2 13090 2 13090 2 15090	2N5427 2N5427 2N5429 2N5051 2N3583 2N5052 2N5051 2N3583 2N5052 2N5052	2-8	3-114 3-114 3-114 3-88 3-20 3-88 3-88 3-20 3-88 3-110	SDT9208 SDT9209 SDT9210 SDT9301 SDT9302 SDT9303 SDT9304 SDT9306 SDT9306 SDT9307	1306 2 1508 2 15024 2 1307 2 1307 2 13090 2 1508 2 1508 2	2N5632 2N5633 2N6569 2N4231A 2N4232A 2N4233A 2N4231A 2N4232A 2N4233A 2N42373 2N3713	2-4 2-4 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8 2-8	3-122 3-122 3-280 3-64 3-64 3-64 3-64 3-64 3-26
SDT6309 SDT6310 SDT6311 SDT6312 SDT6313 SDT6314 SDT6314 SDT6315 SDT6316 SDT6408 SDT6409	कर देश देश देश देश देश देश है।	2N5347 2N5347 2N5347 2N5347 2N5347 2N5347 2N5347 2N5347 2N5347	2-28 2-28 2-28 2-28 2-28 2-28 2-28 2-28	3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-110	SDT9308 SDT9309 SDT9701 SDT9702 SDT9703 SDT9704 SDT9706 SDT9706 SDT9707 SDT12301	2840   2   2   2   2   2   2   2   2   2	2N3715 2N3716 2N5303 2N5629 2N5630 2N5882 2N5629 2N5630 2N3055 2N5039	2-3 2-3 2-5 2-4 2-4 2-4 2-4 2-4 2-4 2-5	3-26 3-98 3-118 3-118 3-118 3-118 3-16 3-6
SDT6410 SDT6411 SDT6412 SDT6413 SDT6414 SDT6416 SDT6416 SDT6901 SDT6902 SDT6903		2N5347 2N5347 2N5347 2N5347 2N5347 2N5347 2N5347 2N5050 2N5051 2N5052	2-28 2-28 2-28 2-28 2-28 2-28 2-8 2-8	3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-88 3-88 3-88	SDT12302 SDT12303 SDT12305 SDT12306 SDT12307 SDT13301 SDT13302 SDT13303 SDT13304 SDT13305	1543   23   24   25   25   25   25   25   25   25	2N5347 2N6546 2N6547	2-28 2-28 2-28 2-28 2-28 2-4 2-4 2-4 2-4 2-4	3-110 3-110 3-110 3-110 3-110 3-263 3-263 3-263 3-984 3-984
SDT6904 SDT7201 SDT7202 SDT7203 SDT7204 SDT7205 SDT7206 SDT7206 SDT7207 SDT7208 SDT7209		2N5052 2N6306 2N6306 2N6306 2N6307 2N6307 2N6308 2N6341 2N6306 2N6306 2N6307	2-3 2-3 2-3 2-3 2-3 2-5 2-3 2-3	3-88 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218 3-218	SDTB01 SDTB02 SDTB03 SDTB05 SDTB06 SDTB07 SE9300 SE9301 SE9302 SE9303	SE9300 SE9301 SE9302	2N5346 2N5346 2N5348 2N5346 2N5346 2N5346 MJ1000	2-19 2-20 2-20 2-3	3-110 3-110 3-110 3-110 3-110 3-110 3-110 3-744
SDT7603 SDT7604 SDT7605 SDT7609 SDT7610 SDT7611 SDT7612 SDT7731 SDT7732 SDT7733	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2N6338 2N6339 2N6341 2N6338 2N6339 2N6341 2N6249 2N5881 2N5881 2N5882	2-3 2-3 2-3 2-5 2-5	3-226 3-226 3-226 3-226 3-226 3-226 3-201 3-143 3-143 3-143	SE9304 SE9306 SE9307 SE9308 SE9331 SE9400 SE9401 SE9402 SE9403 SE9404	SE9400 SE9401 SE9402	MJ1001 MJ4032 MJ4034 MJ4035 2N3739 MJ900 MJ901	2-3 2-4 2-4 2-8 2-19 2-20 2-20 2-3 2-3	3-744 3-756 3-756 3-756 3-377 — — 3-744
SDT7734 SDT7735 SDT7736 SDT9201 SDT9202 SDT9203 SDT9204 SDT9204 SDT9205 SDT9206 SDT9207	64 64 64 64 64 64 64 64	2N5630 2N5631 2N6569 2N5878 2N5632 2N5633 2N6569 2N3055	2-4 2-4 2-4 2-3 2-3 2-3 2-4 2-4 2-4	3-118 3-118 3-118 3-280 3-140 3-122 3-122 3-280 3-6 3-140	SE9406 SE9407 SE9408 SV7056 SVT100-5C SVT200-10 SVT200-10 SVT250-3C SVT250-5	2 1908 2 1909 2	MJ4030 MJ4031 MJ4032 2N6558 2N5632 2N6306 2N6306 MJ15022 2N5838 2N5838	2-4 2-4 2-4 2-13 2-3 2-3 2-3 2-4 2-2	3-756 3-756 3-756 3-277 3-122 3-218 3-102 3-137 3-137

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (beuning) 30M3H333A 880R3-X3QM1

Industry Part Number		Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
SVT250-5C SVT250-10 SVT250-10C SVT300-3C SVT300-5C SVT300-5C SVT300-10 SVT300-10C SVT350-3 SVT350-3C	1202A 2 1238A 2 1231A 2	2N6306 2N6306 MJ15024 2N6307 2N6542 2N6307 2N6307 MJ13090 2N6545 2N6308	2-3 2-3 2-5 2-3 2-2 2-3 2-3 2-4 2-3 2-3	3-218 3-218 3-1020 3-218 3-253 3-218 3-218 3-984 3-259 3-218	SVT7564 SVT7565 SVT7570 SVT7571 SVT7573 SVT7574 SVT7575 TIP29 TIP29A TIP29B	TIP29 TIP29A	MJ13090 MJ13090 MJ13091 MJ16012 MJ13090 MJ13090 MJ16012	2-4 2-4 2-4 2-4 2-4 2-4 2-17 2-17	3-984 3-984 3-984 3-1060 3-984 3-1060 3-1254 3-1254 3-1254
SVT350-5 SVT350-5C SVT350-12 SVT400-3 SVT400-3C SVT400-5 SVT400-5C SVT400-12 SVT450-3 SVT450-3	77 15 2 303 2 303 2 3630 2 3630 2 3630 2 3630 2 3635 2 3638 2	2N5840 MJ13080 2N6547 2N6545 2N6545 2N6543 2N6543 2N6545 MJ13090 2N6545 MJ13334	2-2 2-3 2-4 2-3 2-2 2-2 2-3 2-4 2-3 2-4	3-137 3-978 3-263 3-259 3-253 3-253 3-259 3-984 3-259 3-1002	TIP29C TIP29D TIP29E TIP29F TIP30 TIP30A TIP30A TIP30C TIP30C TIP30D TIP30E	TIP29D TIP29E TIP29F TIP30	2N 2N 2N 2N 2N 2N 2N 2N 2N 2N	2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254 3-1254
SVT450-5 SVT450-5C SVT6000 SVT6001 SVT6002 SVT6060 SVT6061 SVT6062 SVT6062 SVT6051 SVT6251	1347   24   1347   24   1347   24   1347   24   1347   25   1347	2N6543 MJ13080 MJ10004 MJ10004 MJ10005 MJ10004 MJ10005 MJ10006 MJ10006 MJ10006	2-2 2-3 2-5 2-5 2-5 2-5 2-5 2-5 2-3 2-3	3-253 3-978 3-802 3-802 3-802 3-802 3-802 3-802 3-808 3-808	TIP30F TIP31A TIP31A TIP31B TIP31C TIP31C TIP31E TIP31F TIP32 TIP32A	TIP31 TIP31A TIP31B TIP31C TIP31D		2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-1254 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256 3-1256
SVT6253 SVT6546 SVT6547 SVT7520 SVT7521 SVT7522 SVT7523 SVT7524 SVT7525 SVT7530	1346 1346 1346 1346 1346 1346 24 136	MJ10007 MJ13090 MJ13090 2N6543 2N6543 MJ13335 2N6308 2N6543 MJ13334 MJ13334 MJ13381	38 2-2	3-808 3-984 3-984 3-253 3-253 3-1002 3-218 3-253 3-1002 3-978	TIP32B TIP23C TIP32D TIP32E TIP32F TIP33 TIP33A TIP33B TIP33C TIP34	TIP32F TIP33 TIP33A TIP33B TIP33C	2N 2N 2N 2N	2-17 2-17 2-17 2-17 2-17 2-15 2-15 2-15 2-15 2-15	3-1250 3-1250 3-1250 3-1250 3-1260 3-1260 3-1260 3-1260
SVT7531 SVT7532 SVT7533 SVT7534 SVT7535 SVT7540 SVT7541 SVT7542 SVT7543 SVT7544	2 -2 -	MJ13080 MJ16004 MJ13080 MJ13080 MJ16004 MJ16008 MJ16008 MJ16008 MJ13080 MJ13080	∃2 2-31	3-978 3-1030 3-978 3-978 3-1030 3-1045 3-1045 3-1045 3-978	TIP34A TIP34B TIP34C TIP35 TIP35A TIP35B TIP35C TIP35D TIP35E TIP35F	TIP34C TIP35 TIP35A	2N 2N 2N 2N 2N 2N 2N 2N 2N 2N	2-15 2-15 2-15 2-16 2-16 2-16 2-16 2-16 2-16 2-16	3-1260 3-1260 3-1262 3-1262 3-1262 3-1262 3-1262 3-1262 3-1262
SVT7545 SVT7550 SVT7551 SVT7552 SVT7553 SVT7554 SVT7555 SVT7560 SVT7561 SVT7563	6030 2 6031 2 6032 2 632 2 632 2 7506 2 75022 3 8838 2	MJ16008 MJ13091 MJ16010 MJ16010 MJ13090 MJ13091 MJ16010 MJ13091 MJ16012 MJ13090	2-31 2-4 2-10 2-10 2-4 2-4 2-4 2-4 2-4 2-4	3-1045 3-984 3-1060 3-1060 3-984 3-984 3-1060 3-984 3-1060 3-984	TIP36 TIP36A TIP36B TIP36B TIP36C TIP36C TIP36F TIP411 TIP41A TIP41B	TIP36 TIP36A TIP36B TIP36C * * TIP41 TIP41A TIP41B	286 286 286 286 286 286 286 286 286 286	2-16 2-16 2-16 2-16 2-16 2-16 2-16 2-18 2-18 2-18	3-1262 3-1262 3-1262 3-1262 3-1262 3-1266 3-1266 3-1266

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

#### INDEX-CROSS REFERENCE (Continued) (boundard) 30/13/83/38 280/83/49/10

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
TIP41C TIP41D TIP41E TIP41F TIP42 TIP42A TIP42B TIP42C TIP42C TIP42D TIP42E	TIP41C TIP41D TIP41E TIP41F TIP42 TIP42A TIP42B TIP42C TIP42C TIP42D TIP42E		2-18 2-18 2-18 2-18 2-18 2-18 2-18 2-18	3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266	TIP145T TIP146 TIP146T TIP147 TIP147T TIP150 TIP151 TIP152 TIP160 TIP161	TIP145T TIP146 TIP146T TIP147 TIP147T	MJE13006 MJE13007 MJE13007 MJE5740 MJE5741	2-19 2-15 2-20 2-15 2-20 2-19 2-19 2-19 2-19 2-19	3-128 3-128 3-128 3-128 3-128 3-118 3-118 3-115 3-115
TIP42F TIP47 TIP48 TIP49 TIP50 TIP61 TIP61A TIP61B TIP61C TIP62	TIP42F TIP47 TIP48 TIP49 TIP50 TIP61 TIP61A TIP61B TIP61C TIP62		2-18 2-17 2-17 2-17 2-17 2-17 2-17 2-17 2-17	3-1266 3-1270 3-1270 3-1270 3-1270 3-1270 ————————————————————————————————————	TIP162 TIP510 TIP511 TIP512 TIP513 TIP514 TIP517 TIP518 TIP519 TIP520	10009 2 10002 2 10003 2 10073 2 13080 2 13081 2 13095 7 13070 2 13071 2	MJE5742 MJ4248 MJ4247 MJ4248 MJ15012 MJ3238 2N6339 2N6341 MJ4238 MJ4238	2-19 2-3 2-3 2-3 2-2 2-8 2-5 2-5 2-3 2-3	3-115 3-752 3-752 3-752 3-111 3-750 3-226 3-226 3-752 3-752
TIP62A TIP62B TIP62C TIP63 TIP64 TIP73 TIP73A TIP73B TIP74 TIP74A	TIP62A TIP62B TIP62C TIP47 TIP48	2N6486 2N6487 2N6488 2N6489 2N6490	2-17 2-17 2-17 2-17 2-17 2-17 2-20 2-20 2-20 2-20 2-20 2-20	3-1270 3-1270 3-245 3-245 3-245 3-245 3-245 3-245	TIP521 TIP522 TIP523 TIP524 TIP525 TIP526 TIP527 TIP528 TIP536 TIP545	19000 2 19000 2 19000 2 19000 2 19000 2 19000 2 19101 2 19101 3 19070 3	2N6211 2N6211 MJ15012 2N6497 MJ15011 MJ15011 MJ15012 MJ16006 2N6227	2-8 2-8 2-2 2-18 2-2 2-2 2-2 2-2 2-2 2-31 2-2	3-19! 3-19! 3-111 3-24! 3-111 3-111 3-111 3-104
TIP74B TIP75 TIP75A TIP75B TIP75C TIP100 TIP101 TIP102 TIP105 TIP106	TIP100 TIP101 TIP102 TIP105 TIP106	2N6491 MJE13005 MJE13004 MJ13004 MJ13005	2-20 2-18 2-18 2-18 2-19 2-19 2-19 2-19 2-19	3-245 3-1186 3-1180 3-1180 3-1186 3-1274 3-1274 3-1274 3-1274 3-1274	TIP546 TIP550 TIP551 TIP552 TIP553 TIP554 TIP555 TIP556 TIP558 TIP559	1008 3 11018 3 11020 3 13014 7 13015 2 13006 2 13076 3 8547 3	2N6228 MJ12002 MJ12003 MJ12004 MJ12004 MJ13080 MJ13080 MJ13080 MJ16006 MJ16006	2-2 2-2 2-2 2-2 2-2 2-3 2-3 2-3 2-31 2-31	3-133 3-939 3-944 3-946 3-978 3-978 3-978 3-104
TIP107 TIP110 TIP111 TIP112 TIP115 TIP116 TIP117 TIP120 TIP121 TIP121	TIP107 TIP110 TIP111 TIP112 TIP115 TIP116 TIP117 TIP120 TIP121 TIP121		2-19 2-17 2-17 2-17 2-17 2-17 2-17 2-18 2-18 2-18	3-1274 3-1278 3-1278 3-1278 3-1278 3-1278 3-1278 3-1281 3-1281 3-1281	TIP560 TIP562 TIP563 TIP564 TIP565 TIP575 TIP575A TIP575B TIP575C TIP600		MJ16006 MJ16012 MJ16012 MJ11018 MJ10009 MJ13080 MJ13080 MJ13080 MJ13080 TIP100	2-31 2-4 2-4 2-4 2-5 2-3 2-3 2-3 2-5 2-19	3-104 3-106 3-106 3-933 3-814 3-978 3-978 3-978 3-978 3-978
TIP125 TIP126 TIP127 TIP140 TIP140T TIP141T TIP141T TIP142 TIP142T TIP145	TIP125 TIP126 TIP127 TIP140 TIP140T TIP141 TIP141T TIP142 TIP142T TIP145		2-18 2-18 2-18 2-15 2-19 2-15 2-20 2-15 2-20 2-15	3-1281 3-1281 3-1281 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285	TIP601 TIP602 TIP605 TIP606 TIP607 TIP620 TIP621 TIP622 TIP625 TIP626		TIP101 TIP102 TIP105 TIP106 TIP107 TIP120 TIP121 TIP122 TIP125 TIP126	2-19 2-19 2-19 2-19 2-19 2-18 2-18 2-18 2-18 2-18	3-127/ 3-127/ 3-127/ 3-127/ 3-128/ 3-128/ 3-128/ 3-128/ 3-128/ 3-128/

<sup>\*</sup> Consult factory if a direct replacement is necessary.

\*\* To be introduced. Contact factory for Data Sheet.

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page	Industr Part Num		Motorola Direct Replacement	Motorola Similar Replacement	Selector Guide Page	Data Sheet Page
TIP627 TIP640 TIP641 TIP645 TIP646 TIP660 TIP661 TIP662 TIP663 TIP664	24 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	TIP127 2N6384 2N6385 2N6649 2N6650 MJ10002 MJ10002 MJ10003 MJ10001 MJ10008	2-18 2-3 2-3 2-3 2-3 2-3 2-3 2-3 2-5 2-3	3-1281 3-233 3-233 3-233 3-233 3-791 3-791 3-796 3-790 3-814	3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266 3-1266			61 C 61 D 61 E 62 B 62 B 62 B 62 B 62 B 62 B 62 B 63 B 63 B 63 B 63 B 63 B 63 B 63 B 63	AUT AUT AUT AUT AUT AUT AUT AUT AUT AUT	FIPATIC TIPATE TIPATE TIPATE TIPATE TIPATE TIPATE TIPATE TIPATE
TIP665 TIP666 TIP667 TIP668 TIP701 TIP702 TIP702 TIP2955 TIP3055 TIPL751 TIPL751A	265742 24 1743 24 1744 1746 2 1746 12 2 1738 2 1738 2 1738 2 1738 2 1738 2	MJ10009 MJ10002 MJ10003 MJ10013 MJ13080 MJ13081 MJE3055T MJE3055T MJ13070 MJ13071	2-5 2-3 2-3 2-4 2-3 2-3 2-15 2-15 2-2 2-2	3-814 3-791 3-791 3-826 3-978 3-978 3-1289 3-972 3-972	3-1296 3-1270 3-1270 3-1270 3-1270 3-1270	8 71 71 71 71		81 818 818 81C		
TIP752 TIPL752A TIPL753 TIPL753A TIPL755A TIPL755A TIPL757 TIPL757A TIPL760 TIPL760A	7211 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	MJ13090 MJ13091	2-3 2-3 2-3 2-3 2-4 2-4 2-5 2-5 2-5 2-2 2-2	3.978 3.978 3.978 3.978 3.984 3.984 3.990 3.990 3.1200 3.1200	3-1270 3-1270 3-245 3-245 3-245 3-245 3-245	17 17 17 17 17 20 20 20	9487 2 5488 2 6489 2	82A 826 82C 47 48 48 28 28 28 28	新 新 新	
TIPL774 TIPL775 TIPL775A UMT1008 UMT1009 UMT1203 UMT1204 WT5100 WT5200	1278 2 12002 3 12004 3 12004 2 12008 3 13008 2 13006 2 15006 2 15006 2	MJ10009 MJ11018 MJ11020 MJ13014 MJ13015 MJE13004 MJE13005 MJ13015 2N6547	2-5 2-4 2-4 2-3 2-4 2-18 2-18 2-4 2-4	3-814 3-933 3-933 3-966 3-966 3-1180 3-966 3-263	3-245 3-1186 3-1180 3-1186 3-1274 3-1274 3-1274 3-1274 3-1274	00 81 81 81 81 81 81 91	E13004 1 2	M		
3 1046 3 1060 3 1060 4 233 4 233 5 234 5 278 5 278 5 278	18006 28 18012 3 18012 3 11038 3 10008 3 13080 3 13080 3 13080 3	AM   AV   AV   AV   AV		TIPSO TIPSO2 TIPSOS TIPSOS TIPSOS TIPSOS TIPSOS TIPSOS TIPSOS	3-1274 3-1278 3-1278 3-1278 3-1278 3-1278 3-1281 3-1281 3-1281	91 71 71 71 71 81 81 81		107 111 111 115 116 117 117 117 117 117 117 117	前抵斯爾斯斯斯爾斯	
				THP801 THP802 THP803 THP807 THP807 THP802 THP802 THP802 THP802 THP802	3-1281 3-1281 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285 3-1285	81 91 81 81 91 91 90 91 91 91 91 91 91 91 91 91 91 91 91 91		125 126 1427 1407 1407 1447 1447 1427		

\* Consult factory if a direct replacement is necessary.
\*\* To be indicated. Contact factory for Data Sheet.

<sup>\*</sup> Consult factory if a direct replacement is necessary.
\*\* To be introduced. Contact factory for Data Sheet.

#### SELECTION BY PACKAGE

Motorola power transistors are available in a wide variety of metal and plastic packages to match thermal, electrical and cost requirements. The following table compares the basic packages from the standpoint of current, voltage and power capabilities. The devices available in the various packages are tabulated on the succeeding pages.

Fact	egas	ic Range (Amps)	Vcs Range (Volts)	(Waite)	Paga
tor Guid	Selec		40-1500	36-300	2.3
de la	TO-204AE Case 197		40-1500		
ntents	Co	0.8-8.0	40-400		2-8

The selector guides on the subsequent pages offer a quick « first-selection » capability for devices that fit specific applications categories.

Standard Device Selection by Package TO-204 (TO-3) .......

Because designers have different application prerequisite, the devices are categorized in two ways:

- 1. by package
- 2. by major product category

In each case, pertinent electrical characteristics are supplied to permit rapid comparison of potentially suitable devices.

15-100

TO 204 (10-0)	2-2
TO-204AA	2-2
10-39	2-7
TO-66	
TO-126	2-9
TO-127	2-11
Case 152	
TO-202AC	
TO-218	
TO-220AB	
MO-040AA	
	2-22
Power Darlingtons	
Power Switching	2-25
Switchmode	2-31
Cene 240	
BASS-OT POSSOR	
Case 221A	
AACOO ON FILE	
CASE 348	

2-1

2

Page

2-2

#### **SELECTION BY PACKAGE**

Motorola power transistors are available in a wide variety of metal and plastic packages to match thermal, electrical and cost requirements. The following table compares the basic packages from the standpoint of current, voltage and power capabilities. The devices available in the various packages are tabulated on the succeeding pages.

Package	I <sub>C</sub> Range (Amps)	V <sub>CE</sub> Range (Volts)	P <sub>D</sub> (Watts)	Page
TO-204AA (TO-3) Case 1 Case 11	2-30	40-1500	36-300	2-3
TO-204AE Case 197	2.5-70	40-1500	36-300	2-3
TO-205AD (TO-39) Case 79	0.5-5.0	40-400	5-10	2-8
TO-213AA (TO-66) Case 80	that 01:11	1 paq inəupea 280 40-400	lide edt do ee	olug 10109198 1091922-9711 × 7
TO-225AA (TO-126) Case 77		25-400	12.5-40	2-10
TO-225AB Case 90	5-15	sw owt at be 40-100	65-100	seciveb ent
Case 152	0.5-2.0	30-300	luct c&legory	oy package oy m <mark>81-3</mark> r proc
TO-202AC Case 306	704	eine 30-350 io la	of the second section.	in discussion of the
TO-218AC Case 340	12-25	40-400	125-150	2-16
TO-220AB Case 221A	0.5-15	30-750	15-100	2-18
MO-040AA CASE 346	50-300	80-850	300-500	2-22
CASE 353	25-150	80-850	100-250	2-22

2

2-8 2-7 2-8 1-11 1-15 1-15 1-15 1-22 1-23

eneq

TABLE 1 - TO-204AA (Formerly TO-3)

		pnir	ive Switch	Rasist						
(Section)	fr Pn (Case)		1 11		ol (6)	gall	aqy(F so	Den	(ecm (ma))	
A STATE OF THE STA				nsM .		MiniMex	PNP	1/1592/1		Amps Nax
1	9	4.5			4.5			003U8	700	8
20	4 Np	4.5	.4 typ		3	2.25 min		BU209	800	
20	4 1/0	4,5	d bp		4.5	rim 88.9		BURDSA	700	7
CASE 1-0	-01, 11-3 — 4 04, 1-05 — 40			8	8 8			2N3445 2N3447	00	7,6
MODIFIE CASE 19	D TO-3 7-01 — 60 m	il pins			8 8	20/60		2N3446 2N3446	98	
STYLE 1:	BASE	8	1.5 typ	t.5 typ	5	1k min ZEO/18k	18J909 286953	551190 <b>0</b> 2N3055		8
PIN 1. 2. CASE.	EMITTER COLLECTOR	à	1.6 typ		8	1k min 750/13k	WJ991 2M5054		.08	
0.0	OS.	6						11.142.47	120	

125	1 2 1	8 80	3 1.6	1575		Resis	tive Switch	ning	250	
125		8 80	8 8	nim ät		ts	t <sub>f</sub>		f <sub>T</sub>	P <sub>D</sub> (Case
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	2 Device	e Type	a he	@ lc	μs	μs	@ lc	MHz	Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
2.5	700	MJ8500	0.1 6	7.5 min	0.5	4	2	1	95/6	125
125	800	MJ8501	4 8	7.5 min	0.5	(304 <b>4</b> e	2	1	UGA	125
150	1300*	BU204	a.r . a	2 min	2		0.75 typ	2	4 typ	36
150	1400*	MJ205	5 1.5	nim 8			1808	2	450	110
150	1500*	BU205 MJ12002	8 22	2 min 1.11 min	2	2	0.75 typ	2 2	4 typ 4 typ	36 75
3	250	2N5838	0.5	8/40	3	1 typ	0.4 typ	3	5	100
150	275	2N5839	0.6	10/50	2	1 typ	0.4 typ	3	5	100
150	350	2N5840	U.8	10/50	2	1 typ	0.4 typ	3	5	100
3.5	325	2N3902		30/90	-1	1.2 typ	0.1 typ	1	2.8	100
5	40	8	2N4901	20/80	1		2005	CW 1	4	87.5
150	60	3 mas. [	2N4902	20/80	1		Abs	190	4	87.5
150	80	a   gw s.	2N4903	20/80	1		AYRE	UBI	4	87.5
901	120	2N4347	5	15/60	2	2Mode	288	MARS	09	100
159	200	MJ410	9 0.3 M	30/90	1 8	201370	61.0	23%	2.5	100
150	250	MJ3029	0.3 0	30 min	0.4	20160	1778	3		125
150	300	MJ411 2N6542	8 8	30/90 7/35	1 9	4	0.8	3	2.5 6	100 100
115	325	MJ3030	9	3.75 min	3	Teasts	1 11	3		125
150	400	2N6543 MJ13070	3 0.3 04	7/35 8 min	3	4 1.5	0.8 0.5	3	6	100 125
186	450	MJ13071 MJ16002	20.00	8 min 5 min	3 5	1.5	0.5 0.3	3		125 125
160		MJ16004 2N6834	S 0.9 typ	7 min 10/30	5 3	2.7	0.35 0.35	3	15	125 125
150	500	MJ16002A	QA 60 5	5.0 min	5.0	3.0	0.3	3.0	057	125
150	700 700	BU800 MJ8502	6 0.9 tyl	7.5 min	1	4	1 2	4.5 2.5	091	60 150
192	800	MJ8503		7.5 min	13.83	4	2	2.5	908	150
175	850*	MJ12020	2.5	5.0 min	5.0		0.13 typ	3.0	15	125
125	1300*	BU207	8.0	2.25 min	4.5	1	0.6 typ	4.5	4 typ	60
126	1500*	BU208 BU208D† MJ12004	2.5 2.2 6 2.2	2.25 min 2.25 min 2.5 min	4.5 4.5 4.5		0.6 typ 0.6 typ	4.5 4.5 4.5	4 typ 4 typ	60 60 100
6	100	2N5758	2N6226	25/100	3	0.7 typ	0.5 typ	3	1	150
	120	2N5759	2N6227	20/80	3	0.7 typ	0.5 typ	3	1	150
180	140	2N5760	2N6228	15/60	3	0.7 typ	0.5 tvp	3	1	150
175	250	MJ15011	MJ15012	20/100	2		gana	2.50	0.05	200
	375	BU326	8 1.5	30 typ	.6	3.5	0.3 typ	2.5	6 typ	90
175	400	BU326A	81 8	30 typ	.6	3.5	.3 typ	2.5	6 typ	90

†@ 1 MHz

TABLE 1 — TO-204AA (FORMERLY TO-3) (continued)

					Resistive Switching					
						t <sub>s</sub>	t <sub>f</sub>	9	fT	P <sub>D</sub> (Case)
i <sub>C</sub> Cont	V <sub>CEO (sus)</sub>	Device	е Туре	h <sub>FE</sub>	@ lc	μs	μѕ	@ lc	MHz	Watts
	/	NPN	PNP	Min/Max		Max	Max	Amp	Min	@ 25°C
Amps Max	Volts Min		PNP		Amp			-	IVIIII	
6	700	BU500		3 min	4.5	1.2	1	4.5	4.	75
	800	BU209		2.25 min	3	8 typ	.4 typ	4.5	4 typ	20
7	700	BU208A		2.25 min	4.5	8 typ	.4 typ	4.5	4 typ	20
7.5	60	2N3445 2N3447		20/60 40/120	5 5	2 2	0.35 0.35	5	10 10	115 115
	80	2N3446 2N3448		20/60 40/120	5 5	2 2	0.35 0.35	5	10	115
8	60	MJ1000 2N6055	MJ900 2N6053	1k min 750/18k	3 4	1.5 typ	1.5 typ	4	4#	90 100
	80	MJ1001 2N6056	MJ901 2N6054	1k min 750/18k	3 4	1.5 typ	1.5 typ	4	F 4#	90 100 100 A
	120	MJ4247	MJ4237	40 min	3	0.4 typ	0.18 typ	5	20	90
	150	MJ4248	MJ4238	40 min	3	0.4 typ	0.18 typ	5	20	90
	250	2N6306	MJ6502	15/75 15 min	3 2	1.6	0.4 0.5	3 4	5	125 125
	300	2N6307	en of B	15/75	3	1.6	0.4	3	5 - 5	125
	- 20	2N6544	100A 000A	7/35	5	4	Jane	5	6	125
	350	2N6308		12/60	3	1.6	0.4	5	5	125
	400	2N6545	200	7/35	5	4	1,03	5	6	125
	++	MJ13080	MJ6503	15 min	5	1.5	0.5 0.5	4 5	13001	125 150
	AFO		1 3 1	8 min					1300*	
	450	MJ13081 MJ16006		8 min 5 min	5 8	1.5	0.5	5		150 150
	841.7	MJ16008	S	7 min	8	2.2	0.25	5	1300*	150
	3107.5	2N6835		10/30	5	2.5	0.25	. 5	10	150
	500	MJ16006A	80	5.0 min	8.0	3.0	0.4	5.0	2005	150
	850*	MJ12021	100	5.0 min	8.0		0.1 typ	5.0	636	150
	1400*	MJ10011		20 min	4		1000	4	200	80
	1500*	MJ12005		5 min	5	soldine .	1	5	0.6	100
9	400	BUS47		7 min	6	1 typ	.2 typ	6	00	150
	450	BUS47A		7 min	5	1 typ	.2 typ	5	08	150
10	40	2N6383	2N6648	1k/20k	5		VAE	234	20#	100
	60	2N3713	2N3789	15 min	3	0.3 typ	0.4 typ	5	4	150
	1	2N3715	2N3791	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5877	2N5875	20/100	4	1	0.8	4	4	150
	2.5	2N6384 MJ3000	2N6649 MJ2500	1k/20k 1k min	5		28.0	NAC I	20#	100 150
	0	BD311	BD312	25 min	5		000	0.00	-4	115
	80	2N3714	2N3790	15 min	3	0.3 typ	0.4 typ	.5	4	150
	3	2N3716	2N3792	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5878 2N6385	2N5876 2N6650	20/100 1k/20k	5	1	0.8	4	4 20#	150 100
		MJ3001	MJ2501	1k/20k	5	1	2008	1.55	20#	100
	100	2N5632	2N6229	25/100	5	0.9 typ	0.9 typ	5	1	150
	120	2N5633	2N6230	20/80	5	0.9 typ	0.9 typ	5	.1.	150
	140	2N5634	2N6231	15/60	5	0.9 typ	0.9 typ	5	0.1	150
	140	2N3442	2110231	20/70	4	0.5 typ	0.0 190	UB	700	117
	250	MJ15011	MJ15012	20/100	2		0.6.16	11.54	-000	200
	300	MJ3041		250 min	2.5	1	5088	17.60	1000	175
	325	MJ413	0.0	20/80	0.5		97.0	14.000	2.5	125
	GVT-P	MJ423	4.8	30/90	1	-	- 70	URS	2.5	125
	4 199	MJ431	4.5	15/35 8 min	2.5	2.2	0.9	UB	2.5	125 120
	250	11 1 1	6.5	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		2.2	0.9	1.50	0	
	350	MJ3042 MJ13014	3 0.7 60	250 min 8/20	2.5	2	0.5	15	100	175 150
		MJ10002	3 0,7 typ	3/300	5	2.5	1889	5	10#	150
027		MJ10006	3 0.7 100	30/300	5	1.5	0.5	5	10#	150
	1	BU323		350 typ	6	7.5 typ	5.2 typ	.6	020	175
	400	MJ10003 MJ10007	ne n	30/300	5	2.5	0.5	5	10# 10#	150 150
	843.0	MJ10007	8.8	100/2k	6	1.5	15	6	10#	150

# | h<sub>fe</sub> | @ 1 MHz

TABLE 1 — TO-204AA (FORMERLY TO-3) (continued) (C-OT YURZMHOT) AAA0S-OT — / LIBAT

	1	ive Switching	Hosse				tive Switch	ning		D (0)
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Devi	ce Type	h <sub>FE</sub>	@ lc	t <sub>s</sub>	t <sub>f</sub>	@ lc	f <sub>T</sub> MHz	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
10	400	MJ13015	8	8/20	5	2	0.5	5	888	150
180	R	BU323A	19 12	350 typ	6	7.5 typ	5.2 typ	6	981	175
175	450	SDT13304	12 2	10/40	5	1.6 typ	0.35 typ	5	15 typ	125*
175	500	SDT13305	2 61	10/40	5	1.6 typ	0.35 typ	5	15 typ	125*
150	550	MJ10013	8	10/250	10	2.5	0.8	10	09	175
180	600	MJ10014	07 1	10/250	10	2.5	0.8	10	0.9	175
COL	700	MJ8504	10 2.5 M	7.5 min	1.5	4	2	5		175
140	800	MJ8505 MJ16018	6.1 1.01	7.5 min 7.0 min	1.5	2000	2	5 5.0	08	175
200	950*	MJ12010	10 2.5 to	4.2 min	5.0	2.0 typ	0.5 typ	5.0	UG	150
12	40	2N6569	2N6594	15/200	4	5	1.5	2	1.5 to 15	100
180	60	2N6057	2N6050	750/18k	6	1.6 typ	1.5 typ	6	4#	150
120	80	2N6058	2N6051	750/18k	6	1.6 typ	1.5 typ	6	4#	150
250	100	2N6059	2N6052	750/18k	6	1.6 typ	1.5 typ	6	4#	150
180	250	BUX42	81 8	8 min	6	2	.4	6	8	120
150	450	BUX48A	12 1.8	10 min	1	3	.6	8	200	125
175	1000	BUT16	6.6 01	5 min	8	2 typ	.8 typ	8		150
15	60	2N3055H	C.S. 01	20/70	4	- 75	176	UNIT I	800	115
VGI	1 200	2N3055	MJ2955	20/70	4	0.7 typ	0.3 typ	4	2.5	115
175	101	2N3055A 2N6576	MJ2955A	20/70 2k/20k	4 4	2	7000	10	0.8	115 120
175		2N5881	2N5879	20/100	6	1	0.8	6	4	160
175	80	2N5882	2N5880	20/100	6	1	0.8	6	4	160
175	90	2N6577	d.7 D7 1	2k/20k	4	2	7	10	10-200#	120
175	120	MJ15015 2N6578	MJ15016	20/70 2k/20k	4 4	2	7 143	10	1 10-200#	180 120
170	140	MJ15001	MJ15002	25/150	4		8000	S.M	02	200
175	150	MJ11018	MJ11017	100 min	15	STER	1018	11.09	3#	175
250 250 250	200	2N6249 MJ11020 BUX41	MJ11019	10/50 100 min 8 min	10 15 8	3.5	1 .4	10	2.5 3# 8	175 175 120
175	250	MJ11022	MJ11021	100 min	15	1.0	pass	1.00	3#	175
175	275	2N6250	5 4	8/50	10	3.5	1508	10	2.5	175
175	300	2N6546	12 L2 mm	6/30	10	4	0.7	10	6 to 24	175
250		2N6676	20 5	8 min	15	2.5	0.5	15	3	175
250	325	BUX13	8 09	8	8	2.5	.8	8	8	150
250	350	2N6251	16 4.5 W	6/50	10	3.5	1 88	10	2.5	175
200	400	2N6677	10	8 min	15	2.5	0.5	15	3	175
200	400	2N6547 2N6678	1 01	6/30 8 min	10	2.5	0.7	10 15	6 to 24	175 175
200	1 00	MJ13090	7 07	8 min	10	2.5	0.5	10	100	175
200	100	BUS48	01	8 min	10	1.3 typ	.2 typ	10	401	175
200	450	MJ13091 MJ16010	10 1	8 min 5 min	10	2.5 1.2 typ	0.5 0.2 typ	10	120	175 175
200	40	MJ16012	10 1	7 min	15	0.9 typ	0.15 typ	10		175
150	8	2N6836 BUS48A	20 1.2	10/30 8 min	10	3.0	0.35	10	310	175
200	500	MJ16010A	1 01	8 min 5 min	15	1.3 typ	.2 typ	10	205.5	175
000	850*	MJ12022	10 1	5.0 min	15	3	0.1 typ	10	087	175
16	60	MJ4033	MJ4030	1k/	10		3.1 typ	10	003	150
175	80	MJ4034	MJ4031	1k/	10		817	us	400	150
150	100	2N5629	2N6029	25/100	8	1.2 typ	1.2 typ	8	634	200
008	8	MJ4035	MJ4032	08\1k/	10	\$1443E	100	216		150
	2	BD317	BD318	25 min	5	2014/30	CAR	222	0.1	200
	120	2N5630	2N6030	20/80	8	1.2 typ	1.2 typ	8	1	200
200	140	2N3773 2N5631	2N6609 2N6031	15/60 15/60	8	1.1 typ 1.2 typ	1.5 typ 1.2 typ	8	4	150 200
	200	MJ15022	MJ15023	15/60	8	The typ	T.E typ	114	5	250
	8	MJ15026	MJ15027	6 min	16		983	WH.	15	250

# | h<sub>fe</sub> | @ 1 MHz

TABLE 1 — TO-204AA (FORMERLY TO-3) (continued)) (E-OT YJREMEOR) AANOS-OT — FELERAT

		ghire Switching	Hash			Hesisi	ive Switch	ning :		
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Devic	e Type	h <sub>FE</sub>	@ lc	t <sub>s</sub>	t <sub>f</sub> ve μs	@ lc	f <sub>T</sub> MHz	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
-	250	MJ15024	MJ15025	15/60	8	IVICIA	IVICA	Amp	5	250
16	160		MJ15025	1 2 2 2 2 2 2	12	1.2	.25	12	8	120
10	400	BUX41N	5 1.6 tv	8 min		2	.4	12	450	
	-	BUS97	5 1.6 0/4	7 min	12		.4	100	800	175
20	450	BUS97A 2N6257	3 C D	7 min 15/75	10	2	£180	10	2	175 150
20	60	2N3772	as lor l	15/60	10		E100	LIME I	2	150
	- 00	2N6282	2N6285	750/18k	10	2.5 typ	2.5 typ	10	4#	160
	75	2N5039	5 1 35 1	20/100	10	1.5	0.5	10	60	140
	80	2N5303 8.0	2N5745	15/60	10	2	8616	10	2	200
		2N6283	2N6286	750/18k	10	2.5 typ	2.5 typ	10	4#	160
80	90	2N5038	4 5	20/100	12	1.5	0.5	12	60	140
	100	2N6284	2N6287	750/18k	10	2.5 typ	2.5 typ	10	4#	160
	125	BUX40	6 1.5 to	8 min	15	spaste	.25	15	8	120
	140	MJ15003	MJ15004	25/150	5 9	toases I	380	2983	2	250
	160	BUX11N	s a	20/60	8	1.2	.25	15	8	150
	200	BUV11	8	10 min	12	1.8	.4	12	8	150
		MJ13330		8/40	10	3.5	0.7	10	5 to 40	175
	250	MJ13331	100/2-1-0-1	8/40	10	3.5	0.7	10	5 to 40	175
	3.9	BUV12	0.7 (5)	10 min	10	1.5	.5	10	8	150
115	350	MJ10000 MJ10004	4	40/400	10	1.5	1.8	10	10#	175
	16-200#	MJ13332	2 1 2	10/60	5	1.5	0.5	10	10#	175 175
	400	MJ10001	8	40/400	10	3	1.8	10	10#	175
	9-00S-01	MJ10005		40/400	10	1.5	0.5	10	10#	175
	14/0004-01	MJ13100 MJ13333	8   4	8 min 10/60	15	3.5	0.5	15	120	175 175
	av005-011	BUV24	8 4	8 min	12	3	.9	12	8	250
00%	450	MJ10008	101	30/300	10	2	0.6	10	8#	175
217.1	48	MJ13101	l ar	8 min	15	3.5	0.5	15	150	175
	8.5	MJ13334	10 3.5	10/60	5 20	2.7	0.7	10 20	500	175
	48	MJ16014 MJ16016	1 16	5 min 7 min	20	2.7	0.35	20	5000	250 250
	8	2N6837	8 1.5	10/30	15	2.5	0.25	15	15	250
	500	MJ10009	16	30/300	10	1 2	0.6	10	8#	175
	1 25 1	MJ13335	10 3.5	10/60	5	4	0.7	10	275	175
175	700	BUT15	10 4	15 min	12	1.2 typ	.3 typ	12	300	175
	750	MJ10024	15 2.5	50/600	20	5	1.8	10		250
69	850	MJ10025	8 25	50/600	20	5	1.8	10	325	250
24	1000	BUT36	3.5	5 min	16	4.5 typ	1.7 typ	16	359	250
25	60	2N5885	2N5883	20/100	10	1	0.8	10	4	200
175	80	2N5886	2N5884 2N6436	20/100 30/120	10	1	0.8	10	4 40	200
	100	2N6338	2N0430	30/120	10	1	0.25	1,000		
	100	2N0330	2N6437	30/120	10	1	0.25	10	40	200 200
	120	2N6339	6.5 01	30/120	10	1	0.25	10	40	200
		OI COLLAID	2N6438	30/120	10	1	0.25	10	40	200
	125	BUV10	0.8 07	10 min	20	1.2	.25	20	8	150
	1	BUV10N	8 1.3 tvp	10 min	20	1.55	.45	15	10	175
	140	2N6340	15 3	30/120	10	1	0.25	10	40	200
	150	2N6341	10	30/120	10	1	0.25	10	40	200
	500	BUT14	10	15 min	16	1.3 typ	.3 typ	16	- 08	175
28	400	BUT13	30	20 min	18	1.1 typ	.3 typ	18	0.8	175
30	40	2N3771	2N4398	15/60	15	208045	828	2141	02	150
	ha	2N5301		15/60	15%	2	1880	10	2	200
	60	2N5302 MJ11012	2N4399 MJ11011	15/60 1k min	15	2	1 11	10	2 4#	200 200
		2N6326	2N6329	6/30	30	boures		240	3	200
	80	2N6327	2N6330	6/30	30	008462	183	284	3	200
	90	MJ11014	MJ11013	1k min	20	18118	cons	1.36	4#	200
	217	BUX39	81	8 min	20	art to	.25	20	8	120

# | h<sub>fe</sub> | @ 1 MHz

TABLE 1 — TO-204AA (FORMERLY TO-3) (continued)

	4							Resist	tive Switch	hing		
	.,			T				ts	t <sub>f</sub>		f <sub>T</sub>	P <sub>D</sub> (Case
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	-		ice Type	N. ID	hFE	@ lc	μѕ	μs	@ lc	MHz	Watts
Amps Max	Volts Min	-	NPN		PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
30	100	2N6 MJ8	328 302	2N63: MJ45		6/30 25/100	30 7.5				3 2	200 200
	120	MJ.	11016	MJ11	015	1k min	20				4#	200
	325	BU	V23			8 min	16	1.8	.4	16	8	250
	400V	BU	S98			8 min	20	1.55 typ	.2 typ	20		250
	450	MJ	16020 16022 S98A			5 min 7 min 8 min	30 30 16	1.8 1.5 1.55 typ	.2 .15 .2 typ	20 20 16		250 250 250
40	160	BU	V21N			10 min	40	1	.2	40	(0.80 0)	250
	200	BU	V21			10 min	25	1.8	.4	25	8	150
	250		S52			15 min	40	2	.3	40		
		BU	V22	Reset		10 min	20	1.1	.35	20	8	250
	350	MJ	10022			50/600	10	2.5	0.9	20		250
Halls	400		10023	311	00	50/600	10	2.5	0.9	20	(mus) can	250
spac @	700	-	T35	Voll	gmA	15 min	24	2.8 typ	.65 typ	24	nité atlo	250
50	60		11028	2N56 MJ11	029	15/60 400 min	25 50	0.5 typ	0.3 typ	25	2	300 300
	80	2N5	5686	2N56 2N63		15/60 30/120	25 20	0.5 typ 0.8	0.3 typ 0.25	25 20	30	300 250
	90	MJ	11030	MJ11	031	400 min	50	CREAK!			259	300
	100	2N6	274	2N63	78	30/120	20	0.8	0.25	20	30	250
	120		11032 <b>•</b>	2N63 MJ11	79 <b>0</b>	30/120 400 min	20 50	0.8	0.25	20	30	250 300
	125	BU	V20	9.14	0.5	10 min	50	1.2	.25	50	8	250
8	140	2N6	6276 <b>•</b>	01.0	30	30/120	20	0.8	0.25	20	30	250
	150	2N6	277	80.0	0.6	30/120	20	0.8	0.25	20	30	250
	200	BU	S51	0.85	0.5	15 min	50	2	.3	5	- 68	
	400	MJ	10015	0.35	0.5	10 min	40	2.5	1.0	20		250
	500		10016	0.175	0.0	10 min	40	2.5	1.0	20	69	250
56	400	_	T34 T33	-	0.5	15 min	32	1.8 typ	.7 typ	32	08	250
60	200	-	10020	68,0	6.0	20 min 75 min	36	2 typ 3.5	.8 typ	36		250 250
00	250		10021	30.0	0.0	75 min	15	3.5	0.5	30		250
70	60	_	14000	MJ14	001	15/100	50	0.0	0.0	30	001	300
01	80		14002		003	15/100	50	HOGHS	230	285	051	300
	125		S50		20,0	15 min	40	2	.3	40	008	000
	CI CI				0.02	OGFUR			1000	SIVE	230	
	O-3, 60 mil p	ins								-	390	-
h <sub>fe</sub>   @ 1			200	-	0.02	401180				21/2	380	
	180	-	0.038			30/120						1.5
4		1	60:0		1					2843	90	
	150	1	0.036		1			SASTE				
A	250		0.03		-	08/05				2NS	75	-
	250									2345	40	2
	200	0.5			0.5	25/1/20				SWE	00	
	30				d\$.0	50/250					100	-
	3					30/150		294423	2014/337		040	3
8	3 60	1.5	860.0	0.055	0.25	30/150		SMKSS	29/3506		03	
	oa l	1.5	0.036			30/150 40/200			507	2844	08	
10	1 4				4					2514	00	
			0.15		1 2 1			018664				

2NS326 2NB327 2NS338 2NSS39

907

TABLE 2 — TO-39 Package Three (E-OT Y, FREMHOR) AAMES OT — F E. BAT

C		Build	ionwa ew							
111			ý 21.j	1 <sub>n</sub> t 814						trodal
111			xsM	xsM		Min/Max				xah! =qniA
J 008						6/30 25/100	2188331 MJ4662			
008							Brottsai	61917584		
CASE 79-02									325	
STYLE 1:			cyd S.		20			868168	V003	
PIN 1. EMIT 2. BASI			.2 .15 .2 typ			5 min 7 min 8 min		00001186 95319022 9US98A	480	
Pin 3 connected		40			40	nim 01				
	8			8.1	25			19VUB	005	

1.00	0	De 5. 1	8 1 28	15 min		-	100	206	230	-
7.2	- 8	os 8.0	10 25	00808	-	Resist	ive Switc	hing	AND	
icCont	V <sub>CEO</sub> (sus)	0.0	ce Type	h <sub>FE</sub>	@ lc	t <sub>s</sub>	t <sub>f</sub> us	@ lc	f <sub>T</sub> MHz	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
0.5	150	02 QU 0.0	2N4929	20 min	0.05	DOUBLE	40000	0923	100	5
11/1/0	200		2N4930	20 min	0.05			Third I	20	5
676 669	08	85 QVI 8.0	MJ4645	20 min	0.5	0.72*	9386	0.05	40	5
000	250		2N4931	20 min	0.03	125514	0201	12.98	20	5
DES	300	nc 3e.n	MJ4646	20 min	0.5	0.72*	0.653	0.05	40	5
286	400	0.96 30	MJ4647	20 min	0.5	0.72*	agre	0.05	30	5
108	40	2N3110	50	25/70	0.5	0.6*	0.045	0.15	60	5
250	8	08 88	2N3244 2N3467	50/150 40/120	0.5	0.14	0.045	0.5	175 175	5 5
0.83	50	0.25 25.0	2N3245	30/90	0.5	0.12	49,973	0.5	150	5
0.85	30	0.25   20	2N3468	40/120	0.5	0.06	0.03	0.5	175	5
	60	3 5	MM4030	25/40	0.5	0.35	18	PUEL	100/400	7
0.85		08 01	MM4032	70/100	0.5	0.35	63100	LM	150/500	7
S-23	65	08   0.1	MM4036	20/40	0.5	0.175*	62180	11.12	60	7
250	80	2N3019 2N3020	16 6 30	50 min 30/100	0.5		3.6	UU I	100	5
uas	1	0.6   3.0	MM4031	25/40	0.5	0.35	90500	0.00	100/400	7
9.44		WD 500	MM4033	70/100	0.5	0.35	2000	1.439	150/500	7
300	100	2N5681	2N5679	40/150	0.25		08 7207		30	10
700	120	2N5682	2N5680	40/150	0.25	201000	- Charles		30	10
	200	GN C	2N5415	30 min	0.05	2.1.414	0.00	1169	15	5
	250	2N3440		40/160	0.02	i i i i i i i i i i i i i i i i i i i		A STATE OF	15	5
	300		2N5416	30 min	0.05			8/1	15	HOT be 5 of
	350	2N3439		40/160	0.02				15	5
1.5	40		2N3762	30/120	1	0.08	0.035	1	180	4
	50	2N3734		30/120	1	0.03	0.03	1.	250	4
	60	-	2N3763	20/80	1	0.08	0.035	1	150	4
	75	2N3735		20/80	1	0.03	0.03	1	250	4
2	40	2N5859		30/120	0.5	0.035	0.035	0.1	250	5
	60	2N5861		25/120	0.5	0.035	0.035	0.5	200	5
	100	MM3007	MM5007	50/250	0.25				30	8
3	40	2N4237	2N4234	30/150	0.25			-	3	6
	60	2N4238 2N3506	2N4235	30/150 40/200	0.25 1.5	0.055	0.035	1.5	3 60	6 5
	80	2N4239 2N3507	2N4236	30/150 40/200	0.25 1.5	0.055	0.035	1.5	3 60	6 5
4	60	2N4877		20/100	4	1.5	0.5	4	4	10
5	60		MJ8100	25/180	2	1	0.15	2	30	10
	80	2N5336 2N5337	2N6190 2N6191	30/120 60/240	2 2	2 2	0.2 0.2	2 2	30 30	6 6
	100	2N5338 2N5339	2N6192 2N6193	30/120 60/240	2 2	2 2	0.2 0.2	2 2	30 30	10 6

<sup>\*</sup> toff

(B) + 5 c

### TABLE 3 — TO-66 Package package 93 - OT — A BLEAT

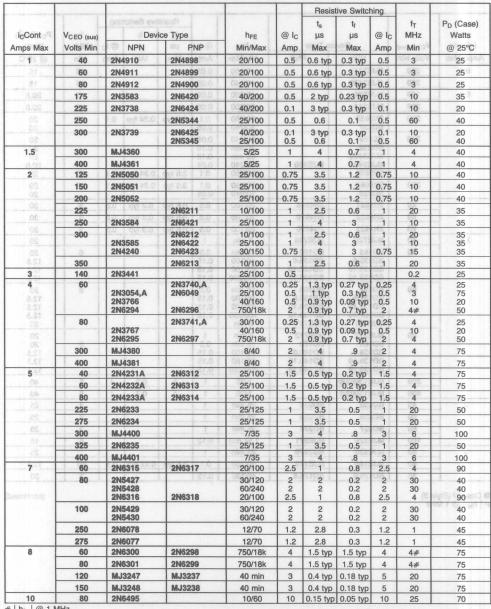




CASE 80-02

STYLE 1:

PIN 1. BASE 2. EMITTER CASE. COLLECTOR



# | h<sub>fe</sub> | @ 1 MHz

### TABLE 4 — TO-126 Packagespanis 98-07 — £ 3.18.AT







CASE 77-04 PLASTIC

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 3:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

CASE 30-02
STYLE 1:
PIN 1: BASE
2: EMITTER
CALE COLLECTOR

i <sub>C</sub> Cont         V <sub>CEO (sus)</sub> Device Type         h <sub>FE</sub> @ I <sub>C</sub> μs         μs         @ I <sub>C</sub> Amps Max         Volts Min         NPN         PNP         Min/Max         Amp         Max         Amp           0.3         250         MJE3440         40/160         0.02         0.02           350         MJE3439         40/160         0.02         0.05           0.5         150         MJE341         25/200         0.05	f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts
i <sub>C</sub> Cont         V <sub>CEO (sus)</sub> Device Type         h <sub>FE</sub> @ I <sub>C</sub> μs         μs         @ I <sub>C</sub> Amps Max         Volts Min         NPN         PNP         Min/Max         Amp         Max         Amp           0.3         250         MJE3440         40/160         0.02         0.02           350         MJE3439         40/160         0.02         0.05           0.5         150         MJE341         25/200         0.05	MHz Min	Watts
Amps Max Volts Min NPN PNP Min/Max Amp Max Max Amp  0.3 250 MJE3440 40/160 0.02  350 MJE3439 40/160 0.02  0.5 150 MJE341 25/200 0.05	Min	
350 MJE3439 40/160 0.02 0.5 150 MJE341 25/200 0.05		@ 25°C
0.5 150 MJE341 25/200 0.05	15	15
200 84 17044	15	15
200 1815244 20/200 0.05	15	20.8
200 MJE344 30/300 0.05	15	20.8
	10:	20
BD157 30/240 0.05	900	20
300 BD158 a a 30/240 0.05		20
BD232 20 min 0.15 MJE3405 65 min 0.12	000	20
MJE340 MJE350 30/240 0.05	400	20.8
	10	20
350 2N5657 30/250 0.1 3.5 typ 0.24 typ 0.1 BD159 30/240 0.05	10	20 20
1 40 2N4921 2N4918 20/100 0.5 0.6 typ 0.3 typ 0.5	3	30
60 2N4922 2N4919 20/100 0.5 0.6 typ 0.3 typ 0.5	3	30
80 2N4923 2N4920 20/100 0.5 0.6 typ 0.3 typ 0.5	3	30
1.5 40 MJE720 MJE710 8 min 1	3000	20
45 BD165 BD166 0 0.15 min 0.5	6	20
BD135.6 BD136.6 40/100 0.15 BD135.10 BD136.10 63/160 0.15	388	12.5
BD135.16 BD136.16 100/250 0.15	03-1	12.5
60 BD167 BD168 15 min 0.5	6	20
BD137.6 BD138.6 40/100 0.15		12.5
BD137.10 BD138.10 63/160 0.15 BD137.16 BD138.16 100/250 0.15		12.5 12.5
MJE721 MJE711 8 8 min 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	08	20
80 MJE722 MJE712 8 min 1		20
BD169   BD170   15 min   0.5	6	20
BD145.0   BD140.0   40/100   0.15	000	12.5 12.5
BD139.16 BD140.16 100/250 0.15	004	12.5
300 MJE13002● 5/25 1 4 0.7 1	5	40
400 MJE13003● 5/25 1 4 0.7 1	5	40
2 45 BD233 BD234 25 min 1	3	25
60 BD235 BD236 25 min 1	3	25
80 BD237 BD238 25 min 1	3	25
100 MJE270 MJE271 1.5k min 0.12	6	15
3 30 MJE520 MJE370 25 min 1	- CON	25
40 MJE180 MJE170 50/250 0.1 0.6 typ 0.12 typ 0.1	50	12.5
45 BD175.6 BD176.6 40/100 0.15	3	30
29,254,20 2 2 0,2 2 30 20		
Case 77 (Style 3) A 8 8.0 F 8.5 007/05 8156/45 8156/45 8156/45		(continue
RM829 30/120 2 2 0.2 2 30 30/120 2 2 0.2 2 30	100	
	290	
	275	1
	08	1 0
	120	
	027	

2

TABLE 4 — TO-126 Package (continued)

						Resis	tive Switch	ning	- 40	
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Device	e Type PNP	h <sub>FE</sub>	@ I <sub>C</sub>	t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub>	f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
3	45	BD175.10 BD175.16	BD176.10 BD176.16	63/160 100/250	0.15 0.15	- Mast	Witter	7 11.15	3	30 30
	60	BD177.6 BD177.10 BD177.16 MJE181	BD178.6 BD178.10 BD178.16 MJE171	40/100 63/160 100/250 50/250	0.15 0.15 0.15 0.1	0.6 typ	0.12 typ	0.1	3 3 3 50	30 30 30 12.5
	80	MJE182 BD179.6 BD179.10 BD179.16	MJE172 BD180.6 BD180.10 BD180.16	50/250 40/100 63/160 100/250	0.1 0.15 0.15 0.15	0.6 typ	0.12 typ	0.1	50 3 3	12.5 30 30 30
	200	BUY49P		30 min	0.5				25	20
4	20	BD433	BD434	50 min	2				3	36
	30	BD185 BD435	BD186 BD436	15 min 50 min	2 2				20 3	40 36
Pg (Case) Welts @ 25°C	40	MJE3300 ● 2N5190 MJE521 2N6037	MJE3310 • 2N5193 MJE371 3N6034	1k min 25/100 40 min 750/18k	1 1.5 1	0.4 typ	0.4 typ	1.5	20 2 25	15 40 40 40
75	45	BD675 BD675A	BD676 BD676A	750 min 750 min	1.5	1348	1.2 typ	1.54	08	40
70 70 75	1 2	BD785 BD187 BD437 BD775	BD786 BD188 BD438 BD776	20 min 15 min 40 min 750 min	2 2 2 2 2	86.05% MJUES 264.593 NA 422 N	11100 11101 078	08.31 28.41 28.41	50 20 3 20	40 15 40 36 15
	60	MJE3301 0 2N5191	MJE3311 0 2N5194	1k min 25/100	1.50	0.4 typ	0.4 typ	1.5	20# 2	15 40
	4,6	MJE800 MJE801 2N6038	MJE700 MJE701 2N6035	750 min 750 min 750/18k	1.5	1.7 typ	1.2 typ	2	1# 1# 25	40 40 40
90	1.5	BD677 BD677A BD787 BD189	BD678 BD678A BD788 BD190	750 min 750 min 20 min 15 min	1.5 2 2 2	MJES BD20 BD20		K16	50 20	40 40 15 40
08	2	BD439 BD777	BD440 BD778	25 min 750 min	2 2	NUE2	10893 25993	Lat   Lat	3 20	36 15
007 007 007	2 2	MJE3302● 2N5192 MJE802 MJE803	MJE3312● 2N5195 MJE702 MJE703	1k min 25/100 750 min 750 min	1 1.5 1.5 2	0.4 typ	0.4 typ	1.5	20# 2 1# 1#	15 40 40 40
06	1 8 1	2N6039 BD679 BD679A BD789	2N6036 BD680 BD680A BD790	750/18k 750 min 750 min 10 min	2 1.5 2 2	1.7 typ	1.2 typ	2	25	40 40 40
		BD769 BD441 BD779 MJE240 MJE241 MJE242	BD790 BD442 BD780 MJE250 MJE251 MJE252	15 min 750 min 40/200 40/120 25 min	2 2 0.2 0.2 0.2				3 20 40 40 40	36 15 15 15 15
	100	MJE244 BD681 BD791 MJE243	MJE254 BD682 BD792 MJE253	25 min 750 min 10 min 40/120	0.2 1.5 2 0.2	0.7 typ	0.08 typ	0.2	40 40 40	15 40 15 15
5	25	MJE200	MJE210	45/180	2		0.035 typ	2	65	15

<sup>●</sup> Case 77 (Style 3) # | h<sub>fe</sub> | @ 1 MHz

TABLE 5 — TO-127 Package

| CASE 90-05 | PLASTIC |
| PIN 1. EMITTER | 2. COLLECTOR | 3. BASE |
| IcCont | VCEO (sus) | Device Type | Min/Max | Amp | Max | Amp | Min | Max | Max | Amp | Min | Max | Max | Max | Amp | Min | Max | M

40	2.0		2	nan 81 am 03	1	Resist	ive Switch	ning	3.0	
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Dev	ice Type	nin od	@ lc	t <sub>s</sub> μs	t <sub>f</sub> µs	@ lc	f <sub>T</sub> MHz	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
5	40	2N5977	2N5974	20/120	2.5	0.45 typ	0.18 typ	2.5	2	75
	50	MJE205	MJE105	25/100	2	0.04283	2715	53.13	-Gm	65
	(60 OS E	MJE1100 MJE1101 2N5978	MJE1090 MJE1091 2N5975	750 min 750 min 25/100	3A 4A 2.5	0.55 typ	0.18 typ	2.5	1 1 2	70 70 75
	80 403 8	MJE1102 MJE1103 2N5979	MJE1092 MJE1093 2N5976	750 min 750 min 20/120	3A 4A 2.5	0.45 typ	0.18 typ	2.5	1 01 2	70 70 75
8	60	MJE6043	MJE6040	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
	80	MJE6044	MJE6041	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
	100	MJE6045	MJE6042	1k/20k	4	1.5 typ	1.5 typ	4	4#	75
10	45		BD206	15 min	4	1000	ATTA	GB	1.5	90
	60	BD207 MJE2801 MJE3055	BD208 MJE2901 MJE2955	15 min 25/100 20/70	4 3 4	8079 8079 8079	989 839 773	08 09 08	1.5	90 90 90
12	40	2N5989	2N5986	20/120	6	0.5 typ	0.25 typ	6	2	100
	60	2N5990	2N5987	20/120	6	0.5 typ	0.25 typ	6	2	100
(54)	80	2N5991	2N5988	20/120	6	0.5 typ	0.25 typ	6	2	100
15	40	MJE1660	MJE1290	20/100	5	TOSEAC	9833	201	3	90
	60	MJE1661	MJE1291	20/100	5	10008	858	aa	3	90

@ Cesr 77 (Style 3)

### 2

# TABLE 7 — TO-202AC Package St 32A3 — 6 3JBAT



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

(COLLECTOR CONNECTED TO TAB)



CASE 200-04 PLASTIC STYLE 11 PN 1: EMITTER D. BASE

					HOTO	THOU	Resis	stive Switch	hing	PLECION	30 .6
							ts	t <sub>f</sub>		fT	P <sub>D</sub> (Case
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Dev Dev	vice Type		hFF	@ 10	μѕ	μѕ	@ lc	MHz	Watts
Amps Max	Volts Min	NPN	1	VP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
0.5	65	MPS-U31	81)	10	10 min	0.1	se Type	reG		Vero rau	10
O785 (B)	300	MPS-U10	MPS-U	60	30 min	0.030	1	14514		60	10
0.8	40	MPS-U02	MPS-U		30 min	0.5		+130	10 KB	150	10
92.8	120	MPS-U03		90.0	40 min	0.010		186	0.0	100	10
30	180	MPS-U04		1880.0	40 min	0.010	6130	191	46	100	10
2	20	BD505	BD506	530.0	90 typ	1	87.49	38	38	180 typ	10
8.25	30	BD507 MPS-U01	BD508 MPS-U		90 typ 50 min	1 1		Mitt	26	180 typ 50	10 10
07	40	MPS-U01A	MPS-U	51A	50 min	1	47.10	0.03	557.1	50	10
6.25	981.6V	MPS-U45	MPS-U	195	4k min	1 1		101	142	100	10
6.25	1 mv1 ex	BD509	BD510	12.71	90 typ	1		801	853	180 typ	10
8.25	45	BD515	BD516	20.00	55 typ	0.5		300	eq	160 typ	10
6.25	60	BD517 MPS-U05	BD518 MPS-U		55 typ 60 min	0.5 0.25		198	PG	160 typ 50	10 10
01	80	MPS-U06	MPS-U		60 min	0.25		1986	285. I	50	10
81.85	508	BD519	BD520		55 typ	0.5		650	NO .	160 typ	10
CF .	100	BD529	BD530		98 typ	0.25	-	2000	950	100 typ	10
6.55	0e	MPS-U07	MPS-U		30 min	0.25		390	100	50	10
	45			0.03	40/180						130
				1.0	30/200						
			1		08/109						
	45/200			80.0	40/180			287	85		
	45/200				40/180						
	45/200				081180		SF76				
	46			0.03	40/180 30 min	06			No.		
	08			80.0				621			
	45				40/180						1
10	45/200			20.0	40/180		8546				
	45/200	0.05.50		20.0			8576	759			
	200 typ 200 typ				nim OF nim OS			101			
102		0.05 typ 1			nim 01		grad				
	200 typ	0.05 typ			nim 07						
	75			8.0	25 min					98	
	900 typ	0.05 typ		1 1							
	200 typ	0.05 typ 1		7	10 min			800			
101	75/350 75/350				000008			415			
	gy1 00S										
		0.05 typ								0.4	
0.1		6 70 0	20.00	200				TO CAME			

Theurite on

# TABLE 7 — TO-202AC Package Sar Baa — a Busar



CASE 306-04 PLASTIC

STYLE 1:

PIN 1. EMITTER

BASE
 COLLECTOR
 COLLECTOR

STYLE 3:

PIN 1. BASE 2. COLLECTOR 3. EMITTER

controlled avitable 4. COLLECTOR

The same

IN : EMITTER
IN : BASE
3. COLLECTOR

(COLLECTOR CONNECTED TO TAB)

2

ettsW	SHM o	@ sri	@ lc µs	neg		Resist	ive Switch	hing	NURS OBOV	deCont.
0 25 C	a Min	Max Astr	Amp Mex	MonMax	98	ts	t <sub>f</sub>		niM fyloV	P <sub>D</sub> (Case)
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Dev	ice Type	nim hre	@ lc	μѕ	μs	@ lc	MHz	Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
0.1	250	D40N1 D40N2 BF787	BF790	30/90 60/180	0.02 0.02 0.025	294	26n+8	438	50-80 50-80 60	6.25 6.25
	300	BF788 D40N3 D40N4	BF791	50 min 50 min 30/90	0.025	0808	9 1304 935 507	08 08	60 50-80	10 10 6.25
	118		DETOO	60/180	0.02	-1279 Wil	LON-S	194	50-80	6.25
0.5	350 30	D40C1 D40C2	BF792	50 min 10k/60k 40k min	0.025 0.2 0.2	0.35 typ 0.35 typ	0.8 typ 0.8 typ	1	60 75 typ 75 typ	6.25 6.25
	9y 40	D40C4 D40C5	0.5	10k/60k 40k min	0.2	0.35 typ 0.35 typ	0.8 typ 0.8 typ	381 381	75 typ 75 typ	6.25 6.25
	120	D40P1	6.0	40 min	0.08	2.5	777	0.08	50	6.25
	150	2N6591	200	40/200	0.1	Coche	tion of	0.00	35	10
	180	D40P3	8:0	40 min	0.08	2.5	519	0.08	50	6.25
	200	2N6592	0.25	30/200	0.1	18083	953	ns l	35	10
	225	D40P5	0.25	40 min	0.08	2.5	S-D02	0.08	50	6.25
	250	2N6557 MDS20 2N6593 BF460 BF757	BF463 BF760	40/180 40/250 30/200 40/180 40/180	0.03 0.03 0.1 0.03 0.03				45 60 35 45/200 45/200	10 10 10 10 10
	300	BF461 BF758 2N6558 MDS21	BF464 BF761 MDS60	40/180 40/180 40/180 30 min 40/250	0.03 0.03 0.03 0.03 0.03				45/200 45/200 45 60 60	10 10 10 10 10
	350	2N6559 BF462 BF759	BF465 BF762	40/180 40/180 40/180	0.03 0.03 0.03				45 45/200 45/200	10 10 10
1	30	D40D1 D40D2	D41D1 D41D2	10 min 20 min	1 1	0.2 typ 0.2 typ	0.05 typ 0.05 typ	1	200 typ 200 typ	10 10
	45	D40D4 D40D5	D41D4 D41D5	10 min 10 min	1	0.2 typ 0.2 typ	0.05 typ 0.05 typ	1	200 typ 200 typ	10 10
	60	2N6551 D40D7 D40D8 BD415 BD385	2N6554 D41D7 D41D8 BD416 BD386	25 min 10 min 10 min 80/300 80/300	0.5 1 1 0.05 0.05	0.2 typ 0.2 typ	0.05 typ 0.05 typ	1	75 200 typ 200 typ 75/350 75/350	10 10 10 10 10
	75	D40D10 D40D11 D40D13 D40D14	D41D10 D41D11 D41D13 D41D14	10 min 10 min 50/150 50/150	1 1 0.1 0.1	0.2 typ 0.2 typ 0.2 typ 0.2 typ	0.05 typ 0.05 typ 0.05 typ 0.05 typ	1 1 1	200 typ 200 typ 200 typ 200 typ	10 10 10 10

TABLE 7 — TO-202AC Package (continued) 9083369 875-07 — 8 318AT

	F-27-111.							Resis	tive Switch	ning	1 000	
								ts	t <sub>f</sub>		fT	P <sub>D</sub> (Case
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)		Dev	rice Type		h <sub>FE</sub>	@ lc	μs	μs	@ lc	MHz	Watts
Amps Max	Volts Min		NPN	F	NP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
1	80		6552	2N655		25 min	0.5				75	10
			417 387	BD41 BD38		80/300 80/300	0.05 0.05				75/350 75/350	10 10
	100	BD	6553 419 389	2N655 BD42 BD39	0	25 min 80/300 80/300	0.5 0.05 0.05				75 75/350 75/350	10 10 10
	150	1	466	0033	0	40 min	0.03				100	10
	180		467	1		40 min	0.1				100	10
	250		468			40 min	0.1				100	10
2	30	_	0E1	D41E	1	10 min	1	0.4 typ	0.17 typ	1	230 typ	8
			0K1	D41K		1k min	1.5	71	,,,		75 typ	10
	40	0.00	0K3	D41K		1k min	1				75 typ	10
Po (Case)	40		412	BD41 BD41		15k min 10k min	0.5				A TEST	10 10
sterW	sHitt		6548	(11)	d 0	5k min	1	ce Type	Dev		100	10
@ 25°C	50	17 (TO 10)	6549 0K2	D41K	oma	3k min 1k min	1.5	9	24,474		75 h/p	10
100	50		0K2 0K4	D41K		1k min	1.5		116002	1.98	75 typ 75 typ	10
100	60	7.10	0E5	D41E	22 1	10 min	1	0.4 typ	0.17 typ	1	230 typ	8
100	80	D4	0E7	D41E	7	10 min	1	0.4 typ	0.17 typ	L1001	230 typ	8
3	40	ME	S26†	MDS7	6†	30 min	1		828	UB	50	12.5
113	60	ME	S27†	MDS7	71.0	30 min	1		ABSS	UEL	50	12.5
Style 3.					8 8	5.0 min 7.0 min			116006 (16008		450	9
100			0.1 typ 0.25	0.75 typ 2.5	8	30 min 5.0 min			9687 A80081H		500	
			0.2 typ	1 two		7 min			9479			
		8			8	7 min				UB		
08	0.6					nim 89		17/26				30
	3.0					nim 0\$		TIPES	33A		08	
125	4.0%	6.0		2.5 byp	10	500 min						
125	+ +		-		8	ik min		avue	ARRY			
08	0.6					20 min	8	APPIN	338			
125	4.0%				10	500 min			141			
125	2.0			2.5 typ	10	20 min 500 min		TIPSA			190	
125	1 101			rifer solve				evas				
125					5	1k mip	35	SDAC	9886	G8		1
125					9	150 min			9838			
		ô	ar			150 min			323AP			
150		5.0	0.5 typ		ŝ	7.0 min			816919	R.M.	008	1
08	2.5				10			11650	9886	977	08	1 08
	3,0#				10	400/15x		F51586	810176		150	-
150	3.0#				10	400/15k		TRITIES	090111		200	
	3.0#		-		10	400/15k	1903	THERE				-
150	+	10	QZ typ	1.3 typ	04	nim 8			SABP		803	
150		10	6.2 typ	1.3 typ	8	8 min 5.0 min			SIBAP		959	
150			0.16	6.	āt	7.0 min			H16012			
150				3.0		5.0 min 40 min			HISOTOA		003	-
	-				10	nim (I)	080	9585.00	94038		60	107
150						1k min		SPILSS	HADDA		56	
125	1.0	0.8	1.2 Lyp	1.2 byp	0.8			DESTABLE	05653		100	
125	1.0		1.2 typ	1.2 typ	0.8	15 min	135	18JEH	E4341 14935	Litt	120	
	-					TR min						
	0.1			t_2 typ	0.8	nim 81	20.00.0	MARK	BASAS			

### TABLE 8 — TO-218 Package (continued) Package (Continued)

1	m 4			Resis						
10000	10)		ST)						VCED (sus)	
. /////	and the				qmA	MinWax	909	MPM		xeM sigmA:
3						25 min 80/360 80/360		214652 BD417 BD417		
CASE 340-01 PLASTIC						rsin 85 606\08 606\08				
STYLE 1:	100				0.1	ginn Gb				
PIN 1. BAS 2. COL	LECTOR				0.1					
3. EMI	TTER									
4. COL	LECTOR	1		0.4 typ		10 min	06103			

0)	997-01			District Co.		Resist	ive Switch	ning	65	-
i <sub>C</sub> Cont Amps Max	V <sub>CEO</sub> (sus)	Devic NPN	e Type	h <sub>FE</sub>	@ I <sub>C</sub>	t <sub>s</sub> μs Max	t <sub>f</sub> μs Max	@ I <sub>C</sub>	f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts @ 25°C
5	450	MJH16002 MJH16004		5.0 min 7.0 min	5 5	3.0	0.30 0.35	3.0	400	100 100
	500	MJH16002A	- A D - E	5.0 min	5	3.0	0.30	3.0	119	100
6	375	BU426		30 typ	0.6	2 typ	0.5 typ	2.5	6	113
80	400	BU426A	l r	30 typ	0.6	2 typ	0.5 typ	2.5	06	113
8	450	MJH16006 MJH16008		5.0 min 7.0 min	8	2.5 2.2	0.25 0.25	5.0 5.0		125 125
	500	BUT50P MJH16008A		30 min 5.0 min	2 8	0.75 typ 2.5	0.1 typ 0.25	5 5.0		100 125
9	400	BUS47P		7 min	5	1 typ	0.2 typ	6		128
	450	BUS47AP		7 min	6	1 typ	0.2 typ	6		128
10	40	TIP33	TIP34	20 min	3				3.0	80
	60	TIP33A TIP140 BDV65	TIP34A TIP145 BDV64	20 min 500 min 1k min	3 10 5	2.5 typ	2.5 typ	5.0	3.0 4.0#	80 125 125
	80	BDV65A TIP33B TIP141	BDV64A TIP34B TIP146	1k min 20 min 500 min	5 3 10	2.5 typ	2.5 typ	5.0	3.0 4.0#	125 80 125
	100	TIP33C TIP142 BDV65B	TIP34C TIP147 BDV64B	20 min 500 min 1k min	3 10 5	2.5 typ	2.5 typ	5.0	3.0 4.0#	80 125 125
	120	BDV65C	BDV64C	1k min	5					125
	350	BU323P		150 min	6	15	15	6		125
	400	BU323AP		150 min	6	15	15	6		125
	800	MJH16018		7.0 min	5	2.0 typ	0.5 typ	5.0		150
15	60	TIP3055	TIP2955	5 min	10				2.5	80
	150	MJH11018	MJH11017	400/15k	10				3.0#	150
	200	MJH11020	MJH11019	400/15k	10				3.0#	150
	250	MJH11022	MJH11021	400/15k	10				3.0#	150
	400	BUS48P		8 min	10	1.3 typ	0.2 typ	10		150
	450	BUS48AP MJH16010 MJH16012		8 min 5.0 min 7.0 min	8 15 15	1.3 typ 1.2 .9	0.2 typ 0.2 0.15	10 10 10		150 150 150
	500	MJH16010A BUT51P		5.0 min 40 min	15 5	3.0 1.1 typ	0.4 0.16 typ	10 10		150 125
16	60	MJH4033	MJH4030	1k min	10					150
	90	MJH4034	MJH4031	1k min	10					150
	100	MJE4340	MJE4350	15 min	8.0	1.2 typ	1.2 typ	8.0	1.0	125
	120	MJE4341 MJH4035	MJE4351 MJH4032	15 min 1k min	8.0 10	1.2 typ	1.2 typ	8.0	1.0	125 150
	140	MJE4342	MJE4352	15 min	8.0	1.2 typ	1.2 typ	8.0	1.0	125
	160	MJE4343	MJE4353	15 min	8.0	1.2 typ	1.2 typ	8.0	1.0	125

# | h<sub>fe</sub> | @ 1MHz

Ton A | big | @ 1 MHz

TABLE 8 — TO-218 Package (continued) applicage 8A0SS-OT — 9 313AT

								Resist	ive Switch	ning	1	
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)		Devi	ice Type	NP	h <sub>FE</sub> Min/Max	@ Ic	t <sub>s</sub> μs Max	t <sub>f</sub> μs	@ Ic	f <sub>T</sub> MHz Min	P <sub>D</sub> (Case) Watts
Amps Max		1000		_			Amp	Max	Max	Amp		@ 25°C
20	60		H6282	MJH62		750/18k	10	BASE	E BLIVTS		4.0#	125
	80		H6283	MJH62		750/18k	10	HUMO	S CHANGE		4.0#	125
0.0	100	-	H6284	MJH62	287	750/18k	10	0.01	0.01	10	4.0#	125
25	40	TIP		TIP36		10/75	15	0.6 typ	0.3 typ	10	3.0	125
	45		249	BD250		10 min	15				3	125
	60		249A 35A	BD250		10 min 10/75	15 15	0.6 typ	0.3 typ	10	3.0	125 125
	80	TIP	35B 249B	TIP36I BD250	В	10/75 10 min	15 15	0.6 typ	0.3 typ	10	3.0	125 125
(Pp (Case) Watts	100		249C 35C	BD250 TIP360		10 min 10/75	15 15	0.6 typ	0.3 typ	10	3.0	125 125
0.62.9	niM	qmA	XBM	XBINI	duly	XSILLAIIM	NV.	donesie -	NI-ANI	Letter 1	TIEN CHOY	Air digiti
h <sub>fe</sub>   @ 1 M			0.4 to									
				0.9 typ						PHIT		
						18/100					0.0	
15	8											
30	10 typ				0.1	15 min 45 min			Trees		088	
	8									mir	- Oh	
	8										90	
		t		gyd 0.0	7	18/76				TIPS		
			gyt 8.0									
			0.3 typ									
	3									11PS		
	8		0.3 190									
								No. of the last				
	10			2 typ				restan		SIT	399	
	10									NUT		
	10		0.18 lyp	2 typ							400	
Oh			9781.0									2
	3									900		
	38.4		1.3 typ					11971			Mosp	
		2		1.7 typ	2			739230				
	1 6 1											
	8					nim čt			390			
			gyT 6.1									
			1.4								400	
Ch	-	1	3.1								450	
		1	8									2.6
65		2										
- 88	-				0.5							
				0.6 typ				11992		Edix	40	3
	3		-					80242				
	8 8									202	00.	
			0.3 typ	gyr 8.0		25 min						
08												
						nim as i		HD242		1902		
	3										120	
40								TIPBE		1183	149	
	8	1	0.3 typ							17893	140	
			175 typ							BUS		
										B&C		4
								DASC1				
		f.	.075	1.				proper	22			
	40	I.	.050		8			DISC2		DAG		
			.075		2	nim 01			100	D148		
30												

TABLE 9 — TO-220AB Package (bourdines) agastas 9815-OT — 8 3.8AT

		ative Switching	Pas							
To (Capr.)	0 4	d su	d (a la	auti		ice Type	Dev			Inc Pair
1/3				xsMn##					Volts Win	xeM comi
		gmA xsM	Amp Max			SHPN	SecaH	-+	93	GS.
		STYLE 1: PIN 1.	BASE or	759/18k			685.8H		08	
738	4.0.4	2.	COLLECTOR			SHINE				
ASE 221A-	02	3.	EMITTER	730/18k				SWIT	100	
LASTIC	3.0	OF   grd 8.04	COLLECTOR	10775		asod	249		48	
			101	10 min		SCON	AGES		08	
126	3.0	0.3 typ 10	15 0.6 be	16/25 16/25	Ä	TIP26	ASS			
1237		0.3 typ 10	16 (J.G-typ	1075	8 86	Resist	tive Switch	ning	f <sub>T</sub>	P <sub>D</sub> (Case)
i <sub>c</sub> Cont	Varia	Devic	e Type	nim h <sub>FE</sub>	@ lc	μs	µs	@ lc	25/5.2"	Watts
Amps Max	V <sub>CEO</sub> (sus) Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
-				-					-	
0.5	40	TIP61	TIP62	15/100	0.5	0.9 typ	0.4 typ	0.5	3 5	M. 1 215 an
	60	TIP61A	TIP62A	15/100	0.5	0.9 typ	0.4 typ	0.5	3	. 15
	80	TIP61B	TIP62B	15/100	0.5	0.9 typ	0.4 typ	0.5	3	15
	100	TIP61C	TIP62C	15/100	0.5	0.9 typ	0.4 typ	0.5	3	15
	350	MJE2360T MJE2361T		15 min 40 min	0.1				10 typ 10 typ	30 30
1	40	TIP29	TIP30	15/75	1	0.6 typ	0.3 typ	1	3	30
	60	TIP29A	TIP30A	15/75	1	0.6 typ	0.3 typ	1	3	30
	80	TIP29B	TIP30B	15/75	-1	0.6 typ	0.3 typ	1	3	30
	100	TIP29C	TIP30C	15/75	1	0.6 typ	0.3 typ	1	3	30
	120	TIP29D	TIP30D	15/75	1	0.6 typ	0.3 typ	1	3	30
	140	TIP29E	TIP30E	15/75	1	0.6 typ	0.3 typ	1	3	30
	160	TIP29F	TIP30F	15/75	1	0.6 typ	0.3 typ	1	3	30
	250	TIP47		30/150	0.3	2 typ	0.18 typ	0.3	10	440
	300	TIP48	MJE5730	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	350	TIP49	MJE5731	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	400	TIP50	MJE5732	30/150	0.3	2 typ	0.18 typ	0.3	10	40
2	45	BD239	BD240	15 min	1				3	30
	60	BD239A TIP110	BD240A TIP115	15 min 500 min	1 2	1.7 typ	1.3 typ	2	3 25#	30 50
	80	TIP111 BD239B	TIP116 BD240B	500 min 15 min	2	1.7 typ	1.3 typ	2	25#	50 30
	100	BD239C TIP112	BD240C TIP117	15 min 500 min	1 2	1.7 typ	1.3 Typ	2	3 25#	30 50
	400	BUX84	111111	300 111111	-	3.5	1.4	1	25#	40
	450	BUX85			_	3.5	1.4	1	_	40
2.5	700	MJE8500		7.5 min	0.5	4	2	1		65
2.0	750	MJE12007		1.1 min	2	-	1.0	2	4 typ	65
	800	MJE8501		7.5 min	0.5	4	2	1	1 4 9 1	65
3	40	TIP31	TIP32	25 min	1	0.6 typ	0.3 tvp	1	3	40
Ü	45	BD241	BD242	25 min	1	o.o typ	o.o typ		3	40
	60	BD241A TIP31A	BD242A TIP32A	25 min 25 min	1 1	0.6 typ	0.3 typ	1	3 3	40 40
	80	TIP31B BD241B	TIP32B BD242B	25 min 25 min	1 1	0.6 typ	0.3 typ	1	3 3	40 40 40
	100	BD241C	BD242C TIP32C	25 min	1 1	065	0.2 5.00	4	3	40 40 40
	120	TIP31C		25 min	1	0.6 typ	0.3 typ	1	3	40
	140	TIP31D TIP31E	TIP32D TIP32E	25 min 25 min	1	0.6 typ		1	3	40
	140	TIP31E	TIP32E	25 min	1		-	1	3	40
		BUS45P	HESEF	6 min	1	0.6 typ	0.3 typ		3	
4	450 30	D44C1		10 min	2	0.4 typ		2	F0	75 30
4	30	D4401	D45C1	10 min	2	.5 .5	.075 .050	.1	50 40	30
		D44C2		20 min	1	.5	.075	.1	50	30
		D44C3	D45C2	20 min 20 min	2	.5 .5	.050	.1	40 50	30 30
		24403	D45C3	20 min	1	.5	.050	.1	40	30
	45	D44C4		10 min	2	.5	.075	.1	50	30
		D44C5	1	20 min	1	.5	.075	.1	50	30

<sup>\*</sup> t<sub>off</sub> # | h<sub>fe</sub> | @ 1 MHz

TABLE 9 — TO-220AB Package (continued)

Po (Case)	1	tive Switching			line.		tive Switch	iing		
	NAME .	1 ® Boule	Type 0 0	l local		t <sub>s</sub>	nusc t <sub>f</sub>	0.1	fT	P <sub>D</sub> (Case)
icCont	V <sub>CEO</sub> (sus)	Devic	e Type	h <sub>FE</sub>	@ lc	μs	μs	@ lc	MHz	Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
4	45	D44C6	10 10 1 6.5 1	20 min	1 1	.5	.075	.1	50	30
50	8.5	2N6121	D45C6 2N6124	20 min 25/100	1.5	0.4 typ	.050	1.5	40 2.5	30
	1 1	BD533	BD534	25 min	2	O.4 typ	0.3 typ	03.82	3	40 50
0.0	60	BD535	BD536	25 min	2	0.0000	5.00	SURA I	3	50
50	6	2N6122	2N6125	25/100	1.5	0.4 typ	0.3 typ	1.5	2.5	40
23	8	MJE800T MJE801T	MJE700T	750 min	1.5	tooms !	100	100	1#	40
03	T nr 1	D44C7	MJE701T	750 min 10 min	2	.5	.075	ust	1# 50	40 30
		0.0.0	D45C7	10 min	2	.5	.050	1	40	30
00	10	D44C8	The second second	20 min	1	.5	.075	7.1	50	30
75	7.5	D44C9	D45C8	20 min 20 min	2	.5	.050	and l	50	30
75	7.5		D45C9	20 min	l i	.5	.050	808	40	30
52	80	D44C10	2.5	10 min	2	.5	.075	74	50	30
80			D45C10	10 min	2	.5	.050	855.1	40	30
08		D44C11	D45C11	20 min 20 min	1 2	.5	.075	108	50	30
70	1	D44C12	D43C11 8	20 min	1 1	.5	.050	100	40 50	30
08			D45C12	20 min	1	.5	.050	J	40	30
70		BD537 2N6123	BD538 2N6126	15 min	2	.5	ALC:	HOLDER	3	50
70		MJE802T	MJE702T	20/80 750 min	1.5	0.4 typ	0.3 typ	1.5	2.5	40 40
76		MJE803T	MJE703T	750 min	2	BD898	ATB	ige	1#	40
08	100	FT317	FT417	20 min	3	0.8 typ	0.5 typ	4	20	40
28	120	FT317A	FT417A	20 min	3	0.8 typ	0.5 typ	4	20	40
08	140	FT317B	FT417B	20 min	3	0.8 typ	0.5 typ	4	20	40
08	300	MJE13004	1 5	6/30	3	3	0.7	3	4	60
70	400	MJE13005		6/30	3	3	0.7	3	4	
5	60	TIP120	TIDADE	THE THE T	100	THE REAL PROPERTY.	-	27000		60
08			TIP125	1k min	3	1.5 typ	1.5 typ	3	4#	65
70	80	TIP121	TIP126	1k min	3	1.5 typ	1.5 typ	. 3	4#	65
70	100	TIP122	TIP127	1k min	3	1.5 typ	1.5 typ	4	4#	75
08	250	MJE51T 2N6497	3 1.5 tv	5 min 10/75	5 2.5	2 typ* 1.8	0.8	2.5	2.5	80
50	300	MJE52T	- 4	5 min	5	150ts 5.2 T	0.0	2.5	20050	80
70	300	2N6498	3	10/75	2.5	2 typ* 1.8	0.8	2.5	2.5	80 80
50	350	MJE53T	4	5 min	5	2 typ*	15030	2.5	2.5	80
00		2N6499	8   0.55 typ	10/75	2.5	1.8	0.8	2.5	5	80
60	400	MJE13070	5 0.55 No	8 min	3	1.5	0.5	3	200	80
08	450	BUS46P	5 3	7 min	3	.40 typ	.175 typ	3	300	80
08		MJE13071	4 Biyp	8 min	3	1.5	0.5	3		80
08		MJE16002 MJE16004		5 min 7 min	5	3 2.7	0.3	3	350	80
08	700	MJE8502	8 1 8	7.5 min	1	4			uac	80
98		A 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	GV/ 8   4	1 1 2 2 2 2 2 2	_		2	2.5	400	80
- 08	800	MJE8503		7.5 min	1	4	2	2.5		80
6	40	TIP41	TIP42	15/75	3	0.4 typ	0.15 typ	3	3	65
60	45	BD243	BD244	15 min	3	Hasq	131	0943	3	65
VC .	60	BD243A TIP41A	BD244A TIP42A	15 min	3	0.44	0.15	-	3	65
.50	80	TIP41B	TIP42B	15/75	3	0.4 typ	0.15 typ	3	3	65
60	80	BD243B	BD244B	15/75 15 min	3	0.4 typ	0.15 typ	3	3	65 65
70	100	TIP41C	TIP42C	15/75	3	0.4 typ	0.15 tvm	3	3	65
. 09	a.r	BD243C	BD244C	15 min	3	U.T typ	0.15 typ	108	3	65
70	120	MJE5180	MJE5170	15/75	3	extos	ABE)	los	3	65
96	1 8.1	TIP41D	TIP42D	15/75	3	0.4 typ	0.15 typ	3	3	65
08	140	MJE5181	MJE5171	15/75	3	CHSHI	747	10.64	3	65
08		TIP41E	TIP42E	15/75	3	0.4 typ	0.15 typ	3	3	65
50	160	MJE5182	MJE5172	15/75	3	0.4588			3	65
125	4.0.0	TIP41F	TIP42F	15/75	3	0.4 typ	0.15 typ	3	3	65
7	30	2N6288	2N6111	30/150	3	0.4 typ	0.15 typ	3	4	40
65	40	2N6129	2N6132	20/100	2.5	0.4 typ	0.15 typ	3	2.5	50
36	45	BD795	BD796	25 min	3	19695	300	198	3	65

TABLE 9 - TO-220AB Package (continued)

\* t<sub>off</sub> # | h<sub>fe</sub> | @ 1 MHz

TABLE 9 — TO-220AB Package (continued) (boundings) sparked 8A0SS-OT — 6 3L8AT

		twe Switching					tive Switch	ning		
668C 69	1	1 1				ts	t <sub>f</sub>		f <sub>T</sub>	P <sub>D</sub> (Case
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)		ce Type	hFE	@ lc	μs	μs	@ lc	MHz	Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
7	50	2N6290	2N6109	30/150	2.5	0.4 typ	0.15 typ	. 3	4	40
	60	2N6130 BD797	2N6133 BD798	20/100	2.5	0.4 typ	0.15 typ	3	2.5	50
	70	2N6292	2N6107	25 min 30/150	3	0.4 typ	0.15 typ	3	3	65
	80	2N6131	2N6134	20/100	2.5	0.4 typ	0.15 typ	3	2.5	50
	2.5	BD799	BD800	15 min	3	Clarity P	o.ro typ	23468	3	65
	100	BD801	BD802	15 min	3	MARTI	7198	LIM .	3	65
	150	BU407	8 1 8 1	30 min	1.5	CHEST !	0.75	5	10	60
	200	BU406		30 min	1.5		0.75	5	10	60
	375	BU522	2 1 2 1	250 min	2.5	50808			7.5	75
	425	BU522A	0.	250 min	2.5	10386	6.0	inject.)	7.5	75
50	450	BU522B		250 min	2.5		gro	100	7.5	75
8	40	2N6386	2N6666	1k/20k	3 0	Descri			20#	65
	45 04 08	BDX53 BD895 BD895A	BDX54 BD896 BD896A	750 min 750 min 750 min	3 4	0840	012	BAG BAG		60 70 70
	60	BDX53A	BDX54A	750 min	3	CONS	337	ing		60
	2.5	TIP130	TIP135	1k/15k	4	20013	122	2516		70
	No. 1	BD897 BD897A	BD898 BD898A	750 min 750 min	3 4	MJE71	7208	1698		70 70
		2N6043	2N6040	1k/10k	4	1.5 typ	1.5 typ	3	4#	75
	98	TIP100	TIP105	1k/20k	3	1.5 typ	1.5 typ	3	4#	80
	80	2N6044	2N6041	1k/10k	4	1.5 typ	1.5 typ	3	4#	75
	20	TIP101 BDX53B	TIP106 BDX54B	1k/20k 750 min	3	1.5 typ	1.5 typ	3	4#	80 60
	4	TIP131	TIP136	1k/15k	4		10081	H-M	360	70
		BD899 BD899A	BD900 BD900A	750 min	3		13035	HAR .	400	70
	100	BDX53C	BDX54C	750 min	4	CHOST.	- 063	chit	- 60	70
	100	TIP132	TIP137	750 min 1k/15k	3 4	11912		WT.		60 70
	456	BD901	BD902	750 min	3	VIP12	22	9IT	100	70
	2.5	2N6045 TIP102	2N6042 TIP107	1k/10k 1k/20k	3	1.5 typ 1.5 typ	1.5 typ 1.5 typ	3	4# 4#	75 80
	120	MJE15028 BDX53D	MJE15029 BDX54D	20 min 750 min	4 3	1.0 typ	TSS	ILSA same	30	50 70
	150	MJE15030	MJE15031	20 min	4	0.55.1	0.788	NUMB	30	50
	200	BU807 BU806	25 18	100 min	5	0.55 typ	0.2 typ	5		60
	300	MJE13006	41 16 1	5/30	5	0.55 typ	0.2 typ 0.7	5	005	60
	500	MJE5740	MJE5850	200 min 15 min	4 2	8 typ	2 typ 0.5	6 4	4	80 80 80
	350	MJE5741	MJE5851	200 min 15 min	4 2	8 typ	2 typ	6		80
	400	MJE5742	MUL3031	200 min	4		0.5	4	905	80
	-	MJE13007	1	5/30	5	8 typ	2 typ 0.7	6	4	80 80
- 28	3	E   qyr er.0	MJE5852	15 min	2	2	0.5	4	04	80
10	30	D44H1 D44H2	D45H1 D45H2	20 min 40 min	4	MSG8	500	BDS	45	50 50
	40	D44E1 31.0	D45E1	1000 min	5	2.0 typ	0.5 typ	10	63	50
	45	D44H4	D45H4	20 min	4	2.0 typ	0.5 typ	min	98	50
	3	D44H5	D45H5	40 min	4	BD24	ESM	:08		50
	3	BDX33 BD805	BDX34 BD806	750 min 15 min	4	THAS	311	AIT I	1.5	70 90
	60	BDX33A	BDX34A	750 min	4	OBLINA	gran san a	11.30	3	70
	8	BD807	BD808	15 min	4	SAGIT	08180	[EAS]	1.5	90
	8	D44E2 D44H7	D45E2 D45H7	1000 min 20 min	5 4	2.0 typ	0.5 typ	10	DST	50 50
	3	D44H8	D45H8	40 min	4	T1P42	318	987		50
	3	TIDIANT	D45H9	40 min	4	054	28182	ILU -	160	50
	3	MJE2801T	TIP145T MJE2901T	500 min 25/100	10	2.5 typ	2.5 typ	5	4.0#	125 75
	4	MJE3055T	MJE2955T	20/70	4	28811	Beg	2898	30	75
	2,5	2N6387 SE9300	2N6667 SE9400	1k/20k	5 8	294610	129	SME	20#	65
22	- 0	SE9300	SE9400	1k min	4	6200	801	(S22)	1#	70

<sup># |</sup> h<sub>fe</sub> | @ 1MHz

ship is a (continued)

TABLE 9 — TO-220AB Package (continued)

		View and the second				Resis	tive Switch	ning		
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Devi	ce Type	h <sub>FE</sub>	@ lc	t <sub>s</sub> µs	t <sub>f</sub> μs	@ lc	f <sub>T</sub> MHz	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C
10	80	D44E3 TIP141T 2N6388 D44H10 D44H11 SE9301 BDX33B BD809	D45E3 TIP146T D45H12 2N6668 D45H10 D45H11 SE9401 BDX34B BD810	1000 min 500 min 40 min 1k/20k 20 min 40 min 1k min 750 min 15 min	5 10 4 5 4 4 4 3 4	2.0 typ 2.5 typ 0.5 typ 0.5 typ	0.5 typ 2.5 typ 0.14 typ 0.14 typ	10 5 5 5	4.0# 20# 50 typ 50 typ 1# 3 1.5	50 125 50 65 50 50 70 70 90
	100	BDX33C TIP142T SE9302	BDX34C TIP147T SE9402	750 min 500 min 1k min	3 10 4	2.5 typ	2.5 typ	5	3 4.0# 1#	70 125 70
Po Case	120	BDX33D	BDX34D	750 min	3				3	70
12	90 84	BUV26			agyTe	cive)	0.15	12	Vego	85
	120	BUV27 BUS36	ghA xsMniM	30 min	10	1.2 0.5 typ	0.40 0.12 typ	8 12	30	85 AA 107
	150	BUS37	40 min	30 min	10	0.5 typ	0.12 typ	12	30	107
	300	MJE13008	40 min 50	6/30	8	3	0.7	8	er 4	100
	400	MJE13009	001 nim 03	6/30	8	3	0.7	8	4	100
15	30	D44VH1	D45VH1	20 min	4	0.7	0.09	8	50 typ	83
	40	2N6486	2N6489	20/150	5	0.6 typ	0.3 typ	5	5	75
-	45 0.1	D44VH4 BDW39	D45VH4 BDW44	20 min 250 min	4 10	0.5	0.09	8	50 typ 4	83 85
	60	BDW40 2N6487 D44VH7	BDW45 2N6490 D45VH7	250 min 20/150 20 min	10 5 4	0.6 typ 0.5	0.3 typ 0.09	5 8	4 5 50 typ	85 75 83
	80	2N6488 D44VH10 BDW41	2N6491 D45VH10 BDW46	20/150 20 min 250 min	5 4 10	0.6 typ 0.5	0.3 typ 0.09	5 8	5 50 typ 4	75 83 85
	100	BDW42	BDW47	250 min	10			No.	4	85
	120	BDW43	BDW48	250 min	10				4	85

<sup># |</sup> h<sub>fe</sub> | @ 1 MHz

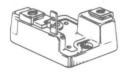


CASE 353-01 MEDIUM CURRENT PACKAGE

Po (Cese) Wests					and		(sus) 0330V	
	Amps	305M	Max		MiniMax		Volts Min	Amps Max
		8 25	100	25 25				8,76
						DARGOTLAM GARGELAM		
	100		4.0	100		MATROAR	250	

# In | @ | MHz

TABLE	10 —	MO-040	AA		tinued)	1100) al	B Packag	220A	-07	RABLE 9
(828) 11 (54)	IT MH2	Registure Suitch	e le	gafi xxMiniMi		ny/T eoly	De Nepes			lcCont
CASE 346-01 HIGH CURRE		2.0 typ 2.1 cm 2.5 typ 2.1 cm 2.5 typ 2.1 cm 2.5 typ 0.14	10 6 6 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	1000 min 500 min 500 min 1 ly20k 20 min 40 min 1k min 750 min 750 min	E3 46T H12 368 H10 H10 601	245 245 245 245 2E9	DAKES TIP1617 DAKES DAKES DAKES SESSON SESSON SESSON SESSON SESSON SESSON SESSON	OS CAGES CHAPT  CAMBSES CHAPT  CAMBTO  CHAPT  CHAPT		
at i	5 4.0#	2.5 typ 2.5 typ 5			BEKSAC		HDX39C TEP142T SERGIO	160		
70	5		10	780 min	340		at <sub>s</sub> xo	t <sub>f 0</sub>	1	P <sub>D</sub> (Case)
i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Devi	ce Type	PNP	h <sub>FE</sub> Min/Max	@ I <sub>C</sub>	μs Max	µs Max	@ I <sub>C</sub>	Watts @ 25°C
Amps Max 75	850	MJ10050 MJ10051	10.	nim GS nim GS	40 min 40 min	50	100 10	35 5	50	500
100	<b>750</b> 8	MJ10052 €	3	6/30	40 min	50	10	5 0	50	
150	450	MJ10100 MJ10101	. 8	688 20 min	60 min 60 min	100	25 3.75	10 1.25	100	- er
15	350	MJ10102	-	021100	60 min	100	3.75	1.25	100	
300	avi 00 8	MJ10200 MJ10201	1	nim 03	90 min 90 min	200	20	1.0	200	
	200	MJ10202	- 07	Tittl USS	90 min	200	4	1	200	
58	5 5 8 50 typ		8		OSP	2N6	2N8487 DA4VH7			
TABLE	5 5 8 50 typ	0.6 typ 0.3 typ 0.09	6 (4 4.	20/150 20 min 250 min	2NG491 D45VH10 BDW46		2N6488 D44VH10 BDW41	D44VH10		
<b>TABLE</b>	IUA		10	250 min	200	VGB	SAWGE	1 0	10	
						van	BDW48			



CASE 353-01 MEDIUM CURRENT PACKAGE

i <sub>C</sub> Cont	V <sub>CEO</sub> (sus)	Device	Туре	h <sub>FE</sub>	@ I <sub>C</sub>	t <sub>s</sub> μs	t <sub>f</sub> μs	@ I <sub>C</sub>	P <sub>D</sub> (Case) Watts
Amps Max	Volts Min	NPN	PNP	Min/Max	Amps	Max	Max	Amps	@ 25°C
37.5	850	MJ10041 MJ10042		25 min 35 min	25 25	10 100	5 35	25 25	250
75	450	MJ10044 MJ10045		50 min 50 min	50 50	3.8 25	1.3 10	50 50	
100	250	MJ10047 MJ10048		75 min 75 min	100 100	4.0 20	1.0	100 100	

## TABLE 11 - Power Darlingtons

						Resid	stive Swift	pnirk			
									Latt		
InoOpl						at I			0	Pp (Case)	
Amps			e Type			Sti	ST		1 10/142	Waits	
Mex	niNi alloV	NPN	PNP	xaMiniM		xsM		qmA		@ 25°C	JEDECINOT
0.5	30	D4001 D4002		10/0/60% 40% min	S.0 S.0		0.8 typ 0.8 typ	1		10	TO-202/306
	-10	DAGGA		10W80K			0.8 typ	T	75 typ		TO-2021:06
6		D4005	DANKS	40k min	0.2			-1-	75 typ		
RY	ON	ECTI	SELI	nim X1	1.5				75 typ		TO-202/906
				5k min	1						TQ-202/306 TQ-202/306
CI	ווחנ	PRO	JOR	MA	1				901		
					0.5						TO-202/506
F	OR	TEG	CA				1 typ		25	10	TO-202/306 TO-220/221A
_	08	TIPESS	02120					1	25		TO-220/231A
		719112	119117	rim #1			1 typ	7		03	TO-220/221A
		MJE270	MJE271	1.5k min	she		de				TO-126/77
4	40	MJE3300	MJE8310	mm air	1				00	15	TO-126/77R
Doo	45	216097	2346034	750 min		1.7 typ					
Pag			ASTRON							40	TQ-126/77
2-2	,						ns	arlingto	ower Da	at P	TO-126/77R
2-2		MAJEBOO	MJE700	750 min	1.5	istors	Trans	witchin	ower S	0% P	
		108SUM	revacw.	nim G85	2						TO-220/221A
2-3			·· Trevelum·	· 1000 0000 1	2	nsistors		ode Po	witchmo		TO-220/221A
		28%038 2M6294	2N6035 2N6236			1.7 typ 0.9 typ			25		
	00	80677	BD673								TO-126/77
		BD677A	BIDEZGA		1.5						TOHENT
		A1JE3302	MJE3312							16	TO-12677R
		MUEBUR	MUEZQZ	750 mln 750 min						40	TO-126/77 TO-220/221A
		E083LW	MUE703		8				1		10-126/77
		TEOSSUM	MUEZOST	750 min	\$				T	40	TO-220/231A
		21/8039	200000		8	1.7 Syp		2 2			TO-126 77
		2M6295 BDB29	21/8297	759/18k	8.1		0.7 fyp	2			
					8						TO-126/77
			BOSB2							40	
8	09	MUE1100								70	TO-127/90
		10112000	MUETORY	750 min	AA				1	70	TO-127/90-
			719126	Birth M.					- B	65	TO-220/221A
		MJE1102 MJE1103	MUE1092 MAE1102	750 min 760 min							
		TIP121		nim obs		1.5 typ	1.5 bp				TO-220/221A
		TIP122	112127	1k min	8		1.5 hp				
4	300	NA13041							-		
	350	1843042			2.5					100	T0-2047
	375	80522							7:5		A19:510:52-OT
	425	BUSSZA							7.5	75	
	025	accaua							7.5		Arssioss-OT
8		2863386		10501							TO-220/22/1A
		56808	80808		8						TO-220/221A
		A88800	A8280G		0						
		BOX53	80X08	1 750 min	8						TO-220/221A
		1997138		16/20lc				8	4		
			246940	Tierrok		1.5 typ					
		2145300	21462393	750k/13k	5				4		
		21/6055	SHEDBS	750k/18k	b.			- 3	4		TO-204/11
		SMOSSLAN	MJE8840 GD898		5	1.5 typ		4			
		T08GS AT08GS		750 min	1						
		BDXSSA	BDYS4A	750 min	6						TO-2207221A

(beamined)

### **TABLE 11** — Power Darlingtons

						Resid	stive Swite	china			
						110010	Suvo Own	Jimig .	h <sub>fe</sub>		
i <sub>C</sub> Cont						ts	t <sub>f</sub>		@	P <sub>D</sub> (Case)	
Amps	V <sub>CEO</sub> (sus)	Device	е Туре	h <sub>FE</sub>	@ lc	μs	μs	@ lc	1 MHz	Watts	Case
Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MOT
0.5	30	D40C1 D40C2		10k/60k 40k min	0.2 0.2	0.35 typ 0.35 typ	0.8 typ 0.8 typ	1	75 typ 75 typ	10 6.25	TO-202/306
	40	D40C4 D40C5		10k/60k 40k min	0.2 0.2	0.35 typ 0.35 typ	0.8 typ 0.8 typ	1	75 typ 75 typ	10 6.25	TO-202/306
2	30	D40K1	D41K1 D41K3	1k min 1k min	1.5 1.5				75 typ 75 typ	10 10	TO-202/306
ik Conti	40	2N6548 2N6549	South State State	5k min	1				100	10	TO-202/306
	Hac	MPS-U45	MPS-U95	3k min 4k min	1				100 100	10 10	TO-202/306 /152
the section	PA AND AND	BD411 BD412	BD413 BD414	15k min 15k min	0.5					10	TO-202/306
pri red	60	TIP110	TIP115	1k min	1	2 typ	1 typ	1	25	10 50	TO-202/306
North period of	80	TIP111	TIP116	1k min	1	2 typ	1 typ	1	25	50	TO-220/221A TO-220/221A
	100	TIP112	TIP117	1k min	1	2 typ	1 typ	1	25	50	TO-220/221A
		MJE270	MJE271	1.5k min	0.12	- 96	. 96		6	25	TO-126/77
4	40	MJE3300 2N6037	MJE3310 2N6034	1k min 750/1k	1 2	1.7 typ	1.2 typ	2	20 25	15 40	TO-126/77R TO-126/77
10 17	45	BD675 BD675A	BD676 BD676A	750 min 750 min	1.5 1.5					40 40	TO-126/77 TO-126/77
12.0	60	MJE3301 MJE800	MJE3311 MJE700	1k min 750 min	1.5		2n	arungid	20	15	TO-126/77R
8-9	100.000 1 1 1 10 10 10	MJE800T	MJE700T	750 min	1.5	stors .	Trans	witching	8 rawo	40 40	TO-126/77 TO-220/221A
E-3		MJE801 MJE801T	MJE701 MJE701T	750 min 750 min	2 2	nsistora	ST Tev	ode Po	mildiw	40	TO-126/77
		2N6038	2N6035	750/18k	2	1.7 typ	1.2 typ	2	25	40 40	TO-220/221A TO-126/77
		2N6294	2N6296	750/18k	2	0.9 typ	0.7 typ	2	4	50	TO/66/80
	60	BD677 BD677A	BD678 BD678A	750 min 750 min	1.5 1.5					40 40	TO-126/77 TO-126/77
	80	MJE3302 MJE802 MJE802T MJE803 MJE803T 2N6039 2N6295 BD679 BD679A	MJE3312 MJE702 MJE702T MJE703 MJE703T 2N6036 2N6297 BD680 BD680A	1k min 750 min 750 min 750 min 750 min 750/18k 750/18k 750 min 750 min	1 1.5 1.5 2 2 2 2 1.5 2	1.7 typ 0.9 typ	1.2 typ 0.7 typ	2 2	20 1 1 1 1 25 4	15 40 40 40 40 40 50 40 40	TO-126/77R TO-126/77 TO-220/221A TO-126/77 TO-220/221A TO-126/77 TO-66/80 TO-126/77 TO-126/77
	100	BD681	BD682	750 min	1.5					40	TO-126/77
5	60	MJE1100 MJE1101 TIP120	MJE1090 MJE1091 TIP125	750 min 750 min 1k min	3A 4A 3	1.5 typ	1.5 typ	3	1 1 4	70 70 65	TO-127/90 TO-127/90 TO-220/221A
	80	MJE1102 MJE1103 TIP121	MJE1092 MJE1102 TIP126	750 min 750 min 1k min	3A 4A 3	1.5 typ	1.5 typ	3	1 1 4	70 70 65	TO-127/90 TO-127/90 TO-220/221A
	100	TIP122	TIP127	1k min	3	1.5 typ	1.5 typ	3	4	65	TO-220/221A
7	300	MJ3041		250 min	2.5	1				100	TO-204/1
	350	MJ3042		250 min	2.5					100	TO-204/1
	375	BU522		250 min	2.5				7.5	75	TO-220/221A
	425	BU522A		250 min	2.5				7.5	75	TO-220/221A
	450	BU522B	0110000	250 min	2.5				7.5	75	TO-220/221A
8	40	2N6386	2N6666	1k/20k	3				20	65	TO-220/221A
	45	BD895 BD895A BDX53	BD896 BD896A BDX54	750 min 750 min 750 min	3 4 3					70 70 60	TO-220/221A TO-220/221A TO-220/221A
	60	MJ1000 TIP100 2N6043 2N6300 2N6055 MJE6043 BD897 BD897A BDX53A	MJ900 TIP105 2N6040 2N6298 2N6053 MJE6040 BD898 BD898A BDX54A	1k min 1k/20k 1k/10k 750k/18k 750k/18k 1k/20k 750 min 750 min 750 min	3 3 4 4 4 4 3 4 3	1.5 typ 1.5 typ 1.5 typ 1.5 typ 1.5 typ	1.5 typ 1.5 typ 1.5 typ 1.5 typ 1.5 typ	3 3 4 4 4	4 4 4 4 2	90 80 75 75 100 75 70 70	TO-204/11 TO-220/221A TO-220/221A TO-66/80 TO-204/11 TO-127/90 TO-220/221A TO-220/221A

TABLE 11 — Power Darlingtons (continued) (baselines) anorgalism source — 14 BLIGAT

		ching		Resistive St		Resistive Swit		ching			
		Last							h <sub>fe</sub>		
Cont	- Committee	D) -91 - 6				ts	t <sub>f</sub>		@	P <sub>D</sub> (Case)	tein Ci
Amps	V <sub>CEO</sub> (sus)	Device	е Туре	hFE	@ lc	μѕ	μѕ	@ lc	1 MHz	Watts	Case
Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MO
8	80	MJ1001	MJ901	1k min	3	5.5	002	THURSDAY	0 000	90	TO-204/11
1 40 US	-07	TIP101	TIP106	1k/20k	3	1.5 typ	1.5 typ	3	4	80	TO-220/221
1105	OT T	2N6044 2N6301	2N6041 2N6299	1k/10k 750k/18k	4	1.5 typ 1.5 typ	1.5 typ 1.5 typ	3	4 4 4 6 5	75 75	TO-220/221 TO-66/80
	-01	2N6056	2N6054	750k/18k	4	1.5 typ	1.5 typ	4	4901	100	TO-204/11
Page	OT	MJE6044	MJE6041	1k/20k	4	1.5 typ	1.5 typ	4	2	75	TO-127/90
	10-2	BD899 BD899A	BD900 BD900A	750 min 750 min	3 4	ET nin	1001	JH11023	1022	70 70	TO-220/221 TO-220/221
058183	10-2	BDX53B	BDX54B	750 min	3	a ni	40 m		91	60	TO-220/221
1/400	100	MJE6045	MJE6042	1k/20k	4	1.5 typ	1.5 typ	4	2 8	75	TO-127/90
	1-01	TIP102	TIP107	1k/20k	3	1.5 typ	1.5 typ	0013 Ht	4 800	80	TO-220/221
	OT.	2N6045 BD901	2N6042 BD902	1k/10k 750 min	4 3	1.5 typ	1.5 typ	3	4 10	75 70	TO-220/221 TO-220/221
	LOT.	BDX53C	BDX54C	750 min	3	or ni	m alt	TEGNHE	334 N	60	TO-220/221
	120	BDX53D	BDX54D	750 min	3	27 mi	a XX a	SEDMI	1 6	70	TO-220/221
	150	BU807		100 min	5	0.55 typ	0.2 typ	5	8 360	60	TO-220/221
	200	BU806	101	100 min	5	0.55 typ	0.2 typ	5	8 8	60	TO-220/221
	300	MJE5740	01	200/400	4	8 typ	2 typ	6	S85	80	TO-220/221
r\hgs	350	MJE5741	101	200/400	4	8 typ	2 typ	6	E   E	80	TO-220/221
	400	MJE5742	1 0	200/400	4	8 typ	2 typ	6	V 100	80	TO-220/221
	500	BUT50P	01	30 min	2	.75 typ	.1 typ	5	TRE	100	TO-218/340
	1400	MJ10011	00	20 min	4	37 08	Avoa	1	4 000	80	TO-204/1
10	40	2N6383	2N6648	1k/20k	5	00 10	40/4		20	100	TO-204/11
	CT .	D44E1	D45E1	1000 min	5	2.0 typ	0.5 typ	10	rer	50	TO-220/221
17.08	45	BDX33	BDX34	750 min	4	00 10	408		3	70	TO-220/221
	60	MJ3000	MJ2500	1k min	5	00 10	6/06		19/000	150	TO-204/1
2041	07	2N6387 2N6384	2N6667 2N6649	1k/20k 1k/20k	5 5 5	00 10	303		20	100	TO-220/221
	-07	D44E2	D45E2	1000 min	5	2.0 typ	0.5 typ	10	20	50	TO204/11 TO-220/221
1205	OT	TIP140	TIP145	500 min	10	2.5 typ	2.5 typ	5	4 # 50	125	TO-218/340
	OT I	TIP140T BDX33A	TIP145T BDX34A	500 min 750 min	10	2.5 typ	2.5 typ	5	3	125 70	TO-220/221
	LOT S	BDV65	BDV64	1k min	5	0. 16	en 2		8:	125	TO-220/221 TO-218/340
	80	MJ3001	2N2501	1k/min	5		n ar i	-	0.1	150	TO-204/1
		2N6388	2N6668	1k/20k	5	es es	25.0		20	65	TO-220/221
		2N6385 D44E3	2N6650 D45E3	1k/20k 1000 min	5	2.0 typ	0.5 typ	10	20	100 50	TO-204/11 TO-220/221
11100	-07	TIP141	TIP146	500 min	10	2.5 typ	2.5 typ	5	4	125	TO-220/221
	07	TIP141T	TIP146T	500 min	10	2.5 typ	2.5 typ	5	4	125	TO-220/221
	01 4	BDX33B BDV65A	BDX34B BDV64A	750 min 1k min	3 5	05 1 09	I WE	110116	3	70 125	TO-220/221 TO-218/340
	100	TIP142	TIP147	500 min	10	2.5 typ	2.5 typ	2.5	4	125	TO-218/340
	01 100	TIP142T	TIP147T	500 min	10	2.5 typ	2.5 typ	5	4	125	TO-220/221
	10-294	BDX33C	BDX34C	750 min	3	31 00	anda T		3	70	TO-220/221
	100 OT	BDV65B BDX33D	BDV64B BDX34D	1k min 750 min	5	0.00	503		0000	125	TO-218/340
	120	BDV65C	BDV64C	1k min	3 5	13 13	15 n		3	70 125	TO-220/221/ TO-218/340
	350	BU323		350 typ	6	7.5 typ	5.2 typ	6	L Dat	175	TO-204/11
	100-204	MJ10002	4	30/300	5	2.5	1.004	5	10	150	TO-204/1
	MCCT] 4	MJ10006		30/300	5	1.5	0.5	5	10	150	TO-204/1
	400	MJ10003 MJ10007●	08	30/300	5 5	2.5	0.5	5	10	150	TO-204/1
	- 1	MJ10012	50	100/2k	6	15	15	6	10	175	TO-204/1 TO-204/1
		BU323A	08-1	350 typ	6	7.5 typ	5.2 typ	6	245	175	TO-204/11
	550	MJ10013	20	10/250	10	2.5	0.8	10	9311	175	TO-204/1
	600	MJ10014	30	10/250	10	2.5	0.8	10	- 01	175	TO-204/1
12	60	2N6057	2N6050	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	80	2N6058	2N6051	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	100	2N6059	2N6052	750/18k	6	1.6 typ	1.5 typ	6	@ 981	150	TO-204/11
ROUTAIS	1000	BUT16●	50	5 min	8	2 typ	.8 typ	8	080	150	TO-204/11
15	60	2N6576	08	2k/20k	4	2	7	10	10/200	120	TO-204/11
	90	2N6577	007	2k/20k	4	2	7	10	10/200	120	TO-204/11
	120	2N6578	T our T	2k/20k	4	2	7	10	10/200	120	TO-204/11

\* toff Darlington with speed-up diode.

TABLE 11 — Power Darlingtons (continued) (beunitness) another in a LIGAT

				AG BAILBISBL		Resis	stive Switch	hing			
		hie I				1			h <sub>fe</sub>		10
i <sub>C</sub> Cont	(888)	(Per (C		1 1		ts	t <sub>f</sub>		@	P <sub>D</sub> (Case)	Amus Vocce
Amps	V <sub>CEO</sub> (sus)	Device	е Туре	h <sub>FE</sub>	@ lc	μs	μѕ	@ lc	1 MHz	Watts	Case
Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MOT
15	150	MJ11018 MJH11018	MJ11017 MJH11017	100 min 100 min	15 15	200 2	1962	12108	3# 3	175 150	TO-204/1 TO-218/340
	200	MJ11020 MJH11020	MJ11019 MJH11019	100 min	15	18k 4	750k/	000004	3#	175 150	TO-204/1 TO-218/340
	250	MJ11022	MJ11021	100 min	15	0k 4	7504	1903317	3#	175	TO-204/1
	500	MJH11022 BUT51P	MJH11021	100 min 40 min	15 5	1.1 typ	.16 typ	10	3	150 125	TO-218/340 TO-218/340
16	60	MJ4033 MJH4033	MJ4030 MJH4030	1km min 1k min	10	3k 4	2011	JE6042	145	150 150	TO-204/1 TO-218/340
	80	MJ4034	MJ4031	1k min	10	Jk A	PAR	20001	2 8	150	TO-204/1
A 12210	90	MJH4034	MJH4031	1k min	10	O min	750	2000	38	150	TO-218/340
	100	MJ4035	MJ4032	1k min	10	E nin	780	03/8/0	e Gr	150	TO-204/1
	120	MJH4035	MJH4032	1k min	10	2 I nis	1001	100000	1	150	TO-218/340
20	60	2N6282	2N6285	750/18k	10	2.5 typ	2.5 typ	10	4	160	TO-204/1
	sor	MJH6282	MJH6285	750/18K	10	2.5 typ	2.5 typ	10	4	125	TO-218/340
	S-CIT 80	2N6283 MJH6283	2N6286 MJH6286	750/18k 750/18K	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 181	160 125	TO-204/1 TO-218/340
	100	2N6284 MJH6287	2N6287 MJH6284	750/18k 750/18K	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4	160 125	TO-204/1 TO-218/340
	○ 350	MJ10000 MJ10004		40/400 40/400	10 10	1.5	1.8 0.5	10	10	175 175	TO-204/1 TO-204/1
A - 25/01	400	MJ10001 MJ10005	01	40/400	10	3	1.8 0.5	10	10	175 175	TO-204/1 TO-204/1
	450	MJ10008	1	30/300	10	2	0.6	10	8	175	TO-204/1
A COSVO	5-0 500	MJ10009		30/300	10	2	0.6	10	8	175	TO-204/1
	700	BUT15	0.	15 min	12	1.2 typ	.3 typ	12		175	TO-204/11
TRUE!	750	MJ10024	1 8	50/600	20	31 5 min	1.8	10	F1 8	250	TO-204/1
	850	MJ10025	0	50/600	20	5	1.8	10	1 70	250	TO-204/1
24	1000	BUT36		5 min	16	4.5 typ	1.7 typ	16	11 3	250	TO-204/197
25	500	BUT140		15 min	16	1.3 typ	.3 typ	16	1 1	175	TO-204/11
	850	MJ10041		25 min 35 min	25 25	10	5 35	25 25	6 0	250 250	—/353 —/353
28	400	BUT13	1 2 1	20 min	18	1.1 typ	.3 typ	18		175	TO-204/11
30	60	MJ11012	MJ11011	1k min	20	S pie	300	DARKS.	4 8	200	TO-204/1
018161	90	MJ11014	MJ11013	1k min	20	in 5	1kn	DVS4A	4	200	TO-204/1
	T120	MJ11016	MJ11015	1k min	20	Dit- pin	500,0	19147	4	200	TO-204/1
40	350	MJ10022	1101	50/600	10	2.5	0.9	20	a di	250	TO-204 Mod/19
	-OT400	MJ10023		50/600	10	2.5	0.9	20	1 8	250	T0-204 Mod/19
	700	BUT35		15 min	24	2.8 typ	.65 typ	24	01	250	TO-204/197
50	60	MJ11028	MJ11029	400 min	50	0 100	020	MITTER	1	300	TO-204 Mod/19
	90	MJ11030	MJ11031	400 min	50	2 00	30/3		50	300	TO-204 Mod/19
	120	MJ11032	MJ11033	400 min	50	8 09	30/3		050	300	TO-204 Mod/19
	400	MJ10015	9	10 min	40	2.5	0.5	20	10	250	T0-204 Mod/19
204	450	MJ10044 MJ10045	9	50 min 50 min	50 50	3.8 2.5	1.3	50 50	12	250 250	—/353 —/353
	500	MJ10016 BUT34	10	10 min 15 min	40 32	2.5 1.8 typ	0.5 .7 typ	20 32	10	250 250	TO-204 Mod/19 TO-204/197
60	200	MJ10020	01	75/1k min	15	3.5	0.5	30	- 000	250	T0-204 Mod/19
	250	MJ10021		75/1k min	15	3.5	0.5	30	0	250	TO-204 Mod/19
75	750	MJ10052		40 min	50	10 19	1025	50	6 6	500	MO-040/346
	850	MJ10050 MJ10051	8	40 min 40 min	50 50	100	35 5	50 50	0.0	500 500	MO-040/346 MO-040/346
100	250	MJ10047 MJ10048	10	75 min 75 min	100	4.0	1.0	100	1	250 250	—/353 —/353

(continued) Carlington with spead-up dode.

<sup># |</sup> h<sub>fe</sub> | @ 1 MHz Darlington with speed-up diode.

TABLE 11 — Power Darlingtons (continued)

							-	Resi	stive Sw			NeV oos	10	oso < 20 sec next or
i <sub>C</sub> Cont Amps	V <sub>CEO</sub> (sus)		Device		atives evin	eiasA FE (	@ lc	t <sub>s</sub> µs	t <sub>f</sub> µs	@ lc	h <sub>fe</sub>   @ 1 MHz	P <sub>D</sub> (Cas		Case
Max	Volts Min	1	IPN	PNP	Min/	Max	Amp	Max	Max	Amp	Min	@ 25°C	JI	EDEC/MOT
150	350	MJ1	0102	al (6)	60	min	100	3.75	1.25	100	Davice	500	N	10-040/346
TECHNIT	450		0100	omA.			100	25	10	100	140	500		10-040/346
300	000	-	0101				100	3.75	1.25	100	1	500		10-040/346
0 808 808	200	-	0202				200	20	1 8	200	8	500	175 345	10-040/346
202/306 04	-07		0201				200	4	021	200	0	500		10-040/346 10-040/346
VT\851-0	T	20					0.5		30/2			april	250	8,0
Darling		peed-u	p diode.				80.	08		8F760 8F463		BF75 BF46		
0-126/77			1				18		n os	200				
	TT							01	30/2		- 81		-	
			45/200			1	93			BF761 BF484		BF75		
			COMON				12			WON TO				
								0		MUESSO				
D-126/77							65							
			45/200				60		40/1	8F762 8F465		BF75		
				.5	gyl E.	6 typ			1905	SNABBS		2N49	0.5	
62,168-0		5	175	0.5	0.045		6.0	60	50/1	29/32/44				
57.6E-0			175	0.5	0.08	80.0			40/1					
D-39/79		5	150	0.5	0.045	0.12	0.0		304	2M3245			98	
6.486-0			175				0.5		40/1		4			
00/88-0		25	- 6	.5		gyl 3.	.5			2141409		28460	00	
		1	09	0.15		1475			201	WR4038				-
08/39-0		25				gg a.		1	20/1		1	EME 1		
			100				1	7	n Ob				150	
												BF48	160	
									11 Oh					
0-39/79							11			2013762				1,5
D-12677							et.		400	HQ136.6		108	45	
2-126777	5 TO						15		100%	80136.16	15.16	BOLD		
			- 8							99798		8016		
67/68-0		b .			0.03				1906			2N37	59	
0+128/77 0+128/77		12.	150		0.035		15		40/1	2N3763 ED 138.6		8013	0.9	
	5 1 70						15		128		7.10	1001		
77785777							15			81.86 (18		BDTS		
22.981-6			3		00.0	-		-		BD168		108		
67/88-0		4		- 1	0.03	E0.6			200			21437	75	
							15		NON NEA	80140,6		8013		
D-128777	T a						16	Gas		30140.16	81.6	BB10		
77/951-0		200	8	-			1 3			20170		108	-	
										303038		18090	BS	. 2
			180 typ				++		1 00				30	
			180 typ 250	1	.035			gy		97208		2058	00	
							TT			BD234				
							1 å					soa	777	
					-05	.035	a.	00	25/1			28458		
D-126/77 202/305.0							80.		25 m	80226		1 8023		
	or						80.		80/3	BD586 BD416	21	BD38		
										81808		ege		
							11					BD2		
	-01													
			qvi 681							BD418				
		31							208	08868				
									E108			8D4		

(batindano)

# TABLE 12 — Power Switching Transistors 19409 — IT BLEIAT

V<sub>CEO</sub> < 200 V (See next page for 200 Volts and greater.)

	211	1 MHz Wa	00	EU 81	1	Resi	stive Swite	ching	Dayton	1	w-V sc A
	OBL O'S	Min © 2		ental sea	01	nA vot	Instit -	SHE	h <sub>fe</sub>	d mike	stoV xati
<sub>C</sub> Cont	14 0	13		0 1 20	. 1	ts	t <sub>f</sub>	-	@	P <sub>D</sub> (Case)	0 600
Amps	VCEO (sus)	Device	DOM:	hFE	@ lc	μѕ	μѕ	@ lc	1 MHz	Watts	Case
Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MOT
0,1	250	BF787	BF790	50 min	.025	io nin	00		60	10	TO-202/306.0
	0 300 €	BF788	BF791	50 min	.025	nia 20	00		60	10	TO-202/306.0
049/348	350	BF789	BF792	50 min	.025	IS   nis	08		60	10	TO-202/306.0
0,5	250	BD157 BF757 BF460	BF760 BF463	30/240 40/180 40/180	.05 .03 .03				45/200 45/200	20 10 10	TO-126/77 TO-202/306.0 TO-202/306.0
	300	BD232 BD158 BF758 BF461 MJE340S MJE340	BF761 BF464 MJE350	20 min 30/240 40/180 40/180 65 min 30/240	.15 .05 .03 .03 .12 .05				45/200 45/200	20 20 10 10 20 20,8	TO-126/77 TO-126/77 TO-202/306.0 TO-202/306.0 TO-126/77 TO-126/77
	350	BD159 BF759 BF462	BF762 BF465	30/240 40/180 40/180	.05 .03 .03				45/200 45/200	20 10 10	TO-126/77 TO-202/306.0 TO-202/306.0
1	40	2N4910	2N4898 2N3244 2N3467	20/100 50/150 40/120	.5 0.5 0.5	.6 typ 0.14 0.06	.3 typ 0.045 0.03	.5 0.5 0.5	3 175 175	25 5 5	TO-66/80 TO-39/79 TO-39/79
	50		2N3245 2N3468	30/90 40/120	0.5 0.5	0.12 0.06	0.045 0.03	0.5 0.5	150 175	5 5	TO-39/79 TO-39/79
	60	2N4911	2N4899	20/100	.5	.6 typ	.3 typ	.5	3	25	TO-66/80
	65		MM4036	20/40	0.5	0.175*		0.15	60	7	TO-39/79
	80	2N4912	2N4900	20/100	.5	.6 typ	.3 typ	.5	3	25	TO-66/80
	150	BF466		40 min	.1				100	10	TO-202/306.0
	180	BF467		40 min	.1				100	10	TO-202/306.0
	250	BF468		40 min	.1				100	10	TO-202/306.0
1.5	40		2N3762	30/120	1	0.08	0.035	1	180	4	TO-39/79
	45	BD135.6 BD135.10 BD135.16 BD165	BD136.6 BD136.10 BD136.16 BD166	40/100 63/160 100/250 15 min	.15 .15 .15				6	12.5 12.5 12.5 20	TO-126/77 TO-126/77 TO-126/77 TO-126/77
	50	2N3734		30/120	1	0.03	0.03	1	250	4	TO-39/79
	60	BD137.6 BD137.10 BD137.16 BD167	2N3763 BD138.6 BD138.10 BD138.16 BD168	20/80 40/100 63/160 100/250 15 min	1 .15 .15 .15	0.08	0.035	1	150	4 12.5 12.5 12.5 20	TO-39/79 TO-126/77 TO-126/77 TO-126/77 TO-126/77
	75	2N3735		20/80	1	0.03	0.03	1	250	4	TO-39/79
	80	BD139.6 BD139.10 BD139.16 BD169	BD140.6 BD140.10 BD140.16 BD170	40/100 63/160 100/250 15 min	.15 .15 .15 .5				6	12.5 12.5 12.5 20	TO-126/77 TO-126/77 TO-126/77 TO-126/77
2	20	BD505	BD506	90 typ	1				180 typ	10	C152
	30	BD507	BD508	90 typ	1				180 typ	10	C152
	40	BD509 2N5859	BD510	90 typ 30/120	.5	.035	.035	.1	180 typ 250	10 5	C152 TO-39/79
	45	BD233 BD515	BD234 BD516	25 min 55 typ	.5				3 160 typ	25 10	TO-126/77 C152
	60	2N5861 BD235 BD385 BD415 BD517	BD236 BD386 BD416 BD518	25/100 25 min 80/300 80/300 55 typ	.5 1 .05 .05	.035	.05	.1	200 3 75/350 75/350 160 typ	5 25 10 10 10	TO-39/79 TO-126/77 TO-202/306.0 TO-202/306.0 C152
	80	BD237 BD387 BD417 BD519	BD238 BD388 BD418 BD520	25 min 80/300 80/300 55 typ	1 .05 .05 .5				3 75/350 75/350 160 typ	25 10 10 10	TO-126/77 TO-202/306.0 TO-202/306.0 C152
	100	BD389 BD419	BD390 BD420	80/300 80/300	.05 .05				75/350 75/350	10 10	TO-202/306.0 TO-202/306.0

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(continued)

TABLE 12 — Power Switching Transistors (continued) assistant pridotive newo9 — \$2 SUBAT

			vitching	Registive Se		Resi	stive Swite	ching			
i <sub>C</sub> Cont	(eas	he   @ Po (O		9		ts	t <sub>f</sub>		h <sub>fe</sub>   @	P <sub>D</sub> (Case)	10000
Amps	V <sub>CEO</sub> (sus) Volts Min		e Type	hFE 2	@ lc	μs	μѕ	@ lc	1 MHz	Watts	Case
Max	The same of the sa	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MOT
2	100	BD529	BD530	98 typ	.25	2 01	0.03	TOURDS	100 typ	10	C152
	120	2N5050	25	25/100	0.75	3.5	1.2	0.75	10	40	TO-66/80
00.00	150	2N5051		25/100	0.75	3.5	1.2	0.75	10	40	TO-66/80
3	OT 40	30 60	2N3719	25/180	2	0.4*	2108	estrate	60	6	TO-5/31
	9-01	DD475.6	2N3867	40/200	2	0.4*	100	1	60	6	TO-5/31
A75576	S-OT-45	BD175.6 BD175.10	BD176.6 BD176.10	40/100 63/160	.15	at m	00.00		3	30 30	TO-126/77 TO-126/77
111405	OT I	BD175.16	BD176.16	100/250	.15	a I as	4024		3	30	TO-126/77
	60	BD177.6	BD178.6	40/100	.15	e 1 03	righ I		3 9	30	TO-126/77
	OT	BD177.10 BD177.16	BD178.10 BD178.16	63/160	.15			13237	3	30	TO-126/77
	OT 1	BD177.10	2N3720	25/180	2	0.4*	00	7825	60	6	TO-126/77 TO-5/31
	8-01	2N3506	8 8	40/200	1.5	0.055	0.035	1.5	60	5	TO-39/79
	OT .	90 90	2N3868	30/150	2	0.4*	40.0	not our	60	6	TO-5/31
	0 80	2N3507	2N6303	30/150 30/150	1.5	0.4*	0.035	1.5	60	6 5	TO-5/31 TO-39/79
	10-2	BD179.6	BD180.6	40/100	.15		0.035		3	30	TO-39/79
06723	OT	BD179.10	BD180.10	63/160	.15		15.40	9080	3	30	TO-126/77
064751	OT OF	BD179.16	BD180.16	100/250	.15	s of	15.0	9020	3	30	TO-126/77
4	20	BD433	BD434	50 min	2	8 00	1000	0100	3	36	TO-126/77
	30	BD185 BD435	BD186 BD436	15 min 50 min	2 2		2019	MS876	20	40 36	TO-126/77
Arsis los	s-or	D44C1	0 1	10 min	2	.5	.075	.1	50	30	TO-126/77 TO-220/221
	10-2	D4400	D45C1	10 min	2	.5	.050	45910*	40	30	TO-220/221
	S-OT	D44C2	D45C2	20 min 20 min	1 2	.5	.075	.1	50	30	TO-220/221 TO-220/221
	TO-2	D44C3	C	20 min	1	.5	.075	.1	50	30	TO-220/221
	S-OT	BD187	D45C3	20 min	1	.5	.050	.1	40	30	TO-220/221
	S-OT	BD437	BD188 BD438	15 min 40 min	2 2				20	40 36	TO-126/77 TO-126/77
	45	BD785	BD786	20 min	2	23 (9)	108		50	15	TO-126/77
	S-01	D44C4	1 12	10 min	2	.5	.075	.1	50	30	TO-220/221
11/105	OT 3	D44C5	D45C4	10 min 20 min	2	.5	.050	.1	40 50	30 30	TO-220/221
	OT C	01100	D45C5	20 min	2	.5	.050	842551	40	30	TO-220/221 TO-220/221
	OT (	D44C6	D45C6	20 min	1	.5	.075	NESSEGO BONDA SO	50	30	TO-220/221
		2N4877	D4500	20 min	1	.5	.050	or Hyran	40	30	TO-220/221
	20	2N4877 BD189	BD190	20/100 15 min	4 2	1.5	nos.5	4	30 20	10	TO-39/79 TO-126/77
	01 (	BD439	BD440	25 min	2	01 0	15/6	W5745	3	36	TO-126/77
	OT	BD787 D44C7	BD788	20 min 10 min	2 2	.5	.075	.1	50	15 30	TO-126/77
	OT 0	0440, 6	D45C7	10 min	2	.5	.050	.1	40	30	TO-220/221 TO-220/221
	S-OT 3	D44C8	D45C8	20 min	1	.5	.075	0210	50	30	TO-220/221
	19-07	D44C9	D45C8	20 min 20 min	2	.5	.050	ADISO	40 50	30 30	TO-220/221 TO-220/221
17/105	OT	05 7 8	D45C9	20 min	1	.5	.050	SHISEM	40	30	TO-220/221
TWOS	80	BD441	BD442	15 min	2	00	100	\$688M	3	36	TO-126/77
	rs-or	BD789 D44C10	BD790	10 min	2 2	.5	.075	86226	40	15	TO-126/77
	2-OT 8	81 8	D45C10	10 min	2	.5	.050	00150	50 40	30	TO-220/221 TO-220/221
	OT C	D44C11	1 01	20 min	1	.5 05	.075	.1	50	30	TO-220/221
1408	OF 1 C	D44C12	D45C11	20 min 20 min	2	.5	.050	150 an	40 50	30	TO-220/221 TO-220/221
	OT 6	DE DA	D45C12	20 min	1	.5	.050	BENOM	40	30	TO-220/221
	01 8	MJE240 MJE241	MJE250	40/200	.2	100	000	440.00	40	15	TO-126/77
	OF I	MJE241	MJE251 MJE252	40/120 25 min	.2	ir no	MAR		40 40	15 15	TO-126/77 TO-126/77
	100	BD791	BD792	10 min	2	10 1 00	tine 1		40	15	TO-126/77
		MJE243	MJE253	40/120	.2	.7 typ	.08 typ	.2	40	15	TO-126/77
FINANS	01 (	MJE244	MJE254	25 min	.2	0	nd1	BEENN	40	15	TO-126/77
5	60	2 2	MJ8100	25/180	2	1 0	0.15	2	30	10	TO-39/79
	08 0 80	2N5337	2N6191	60/240	2	2 0	0.2	2	30	10	TO-39/79
RESOUR	100	2N5339	2N6193	60/240	2	2 09	0.2	2	30	\$8610	TO-39/79
7	60	2N6315	2N6317	20/100	2.5	S 1 05	0.8	2.5	4 8	90	TO-66/80

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noiteshabasano laeria stari en (continued)

TABLE 12 — Power Switching Transistors (continued) additional animative reward — St 3.18AT

			gnidolini	Resistive S		Resi	stive Switch	hing			
		Dia							h <sub>fe</sub>		
i <sub>C</sub> Cont	(988)	0) 09 0	1	1 1		ts	t <sub>f</sub>		@	P <sub>D</sub> (Case)	InsOp
Amps	V <sub>CEO</sub> (sus)		Туре	BU hFE 8	@ lc	μѕ	μs	@ lc	1 MHz	Watts	O30 Case
Max	Volts Min	NPN	PNP	Min/Max	Amp	Max	Max	Amp	Min	@ 25°C	JEDEC/MOT
7.	80	2N5428 2N5347	2N6187	60/240 60/240	2 2	2 2	0.2	2	30	60	TO-66/80 TO-59/160
	0	2N6316	2N6318	20/100	2.5	1	0.8	2.5	4	90	TO-66/80
	100	2N5430	0.0	60/240	2	2	0.2	2	30	60	TO-66/80
	)T	2N5349	2N6189	60/240	2	2 0	0.2	2	30	60	TO-59/160
	150	BU407		30 min	1.5	7 1 10	.75	5	10	60	TO-220/221
coast	200	BU406		30 min	1.5	0.	.75	5	10	60	TO-220/221
7.5	60	2N3447		40/120	5	2	0.35	5	10	115	TO-204/11
Then	80	2N3448		40/120	5	2	0.35	5	10	115	TO-204/11
8	120	MJ3247	MJ3237	40 min	3	0.4 typ	0.18 typ	5 0	20	75	TO-66/80
	M	MJ4247 MJE15028	MJ4237 MJE15029	40 min 20 min	3	0.4 typ	0.18 typ	5	20	90	TO-204/11
	150	MJ3248	MJ3238	40 min	3	0.4 typ	0.18 typ	5	20	50 75	TO-220/221 TO-66/80
	130	MJ4248	MJ4238	40 min	3	0.4 typ	0.18 typ 0.18 typ	5 34	20	90	TO-204/11
82/68	01	MJE15030	MJE15031	20 min	1.04	0.4 typ	0.18 typ	5	30	50	TO-220/221
10	45	3 2	BD206	15 min	4	2. 08	63/1		1.5	90	TO-127/90
	60	BD207	BD208	15 min	4	50 .13	100/2	at.081G	1.5	90	TO-127/90
	OT .	2N5877	MJ6700 2N5875	25/180 20/100	2 4	S 1 ni	0.15	4	30	150	TO-59/160 TO-204/11
	80	2N5878	2N5876	20/100	4	\$ 1	0.8	4	4	150	TO-204/11
	00	D44H10*		20 min	4	.5	.14	5	1 4	50	TO-220/221
1158 75	S OT	40 30	D45H10*	20 min	4	.5	.14	5		40	TO-220/221
	150	BU807	Tr.	100 min	5	.55 typ	.2 typ	5	8	60	TO-220/221
120/03	200	BU806		10 min	5	.55 typ	.2 typ	5		60	TO-220/221
12	90	BUV26	T.	180.		1 10	.15	12		85	TO-220/221
	120	BUV27 BUS36*		30 min	10	1.2 .5 typ	.40 .12 typ	8 12	30	85 107	TO-220/221 TO-220/221
4 SSWIS	150	BUS37★	1.	30 min	10	.5 typ	.12 typ	12	30	107	TO-220/221
15	60	2N3055H 2N5881	2N5879	20/70 20/100	4 6	5 1	0.8	6	800 4	115 160	TO-204/11 TO-204/11
	80	2N5882 D44VH.10*	2N5880 D45VH.10*	20/100 20 min	6 4	1 .5	0.8	6	4 50 typ	160 83	TO-204/11 TO-220/221
20	75	2N5039	4	20/100	10	1.5	0.5	10	60	140	TO-204/1
	80	2N5303	2N5745	15/60	10	2	ae1	10	2	200	TO-204/11
	90	2N5038		20/100	12	1.5	0.5	12	60	140	TO-204/1
	125	BUX40*	1 .	8 min	15	o 1 m	.25	15	8	120	TO-204/11
25	45	BD249	BD250	10 min	15	f ni	102		3	125	TO-218/340.
	60	BD249A	BD250A	10 min	15	7 10	0.08	85289	3	125	TO-218/340.
	Tor I	2N5885	2N5883	20/100	10	1	0.8	10	4	200	TO-204/11
	80 OT	2N5886 BD249B	2N5884 2N6436 BD250B	20/100 30/120 10 min	10 10 15	S i ni	0.8 0.25	10	4 40 3	200 200 125	TO-204/11 TO-204/1
	100	BD249C	BD250C	10 min	15	2 ni	10.1	61088	3	125	TO-218/340. TO-218/340.
	S-07	2N6338	t.	30/120	10	1 0	0.25	10	40	200	TO-204/1
	8-01 I	40 34	2N6437	30/120	10	S 1 m	0.25	10	40	200	TO-204/1
	120	2N6339	2N6438	30/120 30/120	10	1 1	0.25 0.25	10	40	200	TO-204/1 TO-204/1
	125	BUV10N*		10 min	20	1.55	.45	15	10	175	TO-204/11
	140	2N6340		30/120	10	1	0.25	10	40	200	TO-204/11
	150	2N6341		30/120	10	S 1 Di	0.25	10	40	200	TO-204/1
	01	2N5301	2N4398	15/60	15	2	0.23	10	2	200	TO-204/11
30	I An		-117030				1/201	10	2	200	
30	60	2N5302	2N4399	15/60	7.5						
9718	60	2N5302	2N4399	15/60	15	2 00	200		2	200 [	TO-204/11
30	The same of the same of	2N5302 08 08 2N6274 08	2N4399 2N6377 2N6378	30/120 30/120	20	0.8	0.25	20	30	250	TO-204/11 TO-204 Mod/1 TO-204 Mod/1

<sup>★</sup> Designers Data Sheet characterization

(continued)

TABLE 12 — Power Switching Transistors (continued)

							Resis	tive S	witching			V <sub>GEO</sub> ≥ 200 V
i <sub>C</sub> Cont Amps	V <sub>CEO</sub> (sus)	De	evice Ty	ne a said	h <sub>FE</sub>	@ lc	t <sub>s</sub>	t <sub>f</sub>	@ lc	h <sub>fe</sub>   @	P <sub>D</sub> (Case) Watts	Case
Max	Volts Min	NPN	1	PNP	Min/Max	Amp	Max	Max		Min	@ 25°C	JEDEC/MOT
50	125	BUV20*	16	en en	10 min	50	1.2	.25	50	8 8 10	250	TO-204/197
TOMS	30 140	2N6276	aniA	XsM	30/120	20	0.8	0.25		30	250	TO-204 Mod/197
	150	2N6277	86	Court V I	30/120	20	0.8	0.25		30	250	TO-204 Mod/197
70	125	BUS50*		ovt 8	15 min	40	2	.3	40	0.04	12	TO-204/197
Design	ners Data S	heet chara	otorizati	35	001	So	min (		±=080010A			859
Design	ners Data S	neet chara			01		nim (		**************************************			
	A			85					\$4310042# #			
	S-OT		5	2			nim a		MJ8505 ±			
	10-2		5.0	0.9 typ	2.0 typ				*8100114			
				0.9 typ					*81081111			
		d Ivo			gyl 8	3						
	TO-220				1	0.1			WISSO3*			
	S-07				-	0.5						
	10-22		1	2			nim è		WINE DEBUT #			
							nim (		N-1 (1052 # W	006		750
					8			18 4	**********	000		
						8		8	Ad12005		8	
		4 k/p	4.5				nim 3	8	#W12604#	500	1 9	
	S-OT	4.190		1 1		3					4	
	s-or	4 typ	2	1					W112002*			
	ISS-OF	4 1/10							MJE12007*			
						24	oim è					706
					1.2 typ							
			ð				nim 8		A18201+			
	10-2		A					YS.	a treona	1 00%		
fWid		4 0/0		4 typ		4.5		2.8	ABUSUS	998	7	
TIME			4.5		1.8	4.5		3			8	
	S-OT				- 8				W18802 #			
				9 qyi 8.0	4	4.5	5 min 15 min		#JESS024 SU2030			
	25-07							-				
	S-OT				- 4		nim 8		#0038U0	200		
A1SSIA	10-220								* 00285UN			
					2.5		0/250		#4.0014.#			008
	S-OT								WJ10013##			560
									WJ10016##			590
	TOS				1.3 typ				3UT14###	-		
	10-2	**8	10	8.0	S				## £0000 ##			
	s-or			0.7	1				#8000FLA			
				10.0	0.8				*AUTOSTLA			
				0.4		15.0	nim 0	18	\$3H16019A* \$UT\$1P **			
	rs-ot rs-ot	-		l gys 81.	75 typ				SUYSOF ##			
04/1	S-OT			0.4		15.0			#ASODSILA			
	10-21			5.0				5.0		000		
				0.3			nim 0		+ASSOSSILW			
	TO-21		3.0		3.0				*ASCORPHUM *ASCORPHUM			450
	MO-D4		100	1.25			nim 6		W110101##			450
				1.3	8.8							
			50.0	01	25				** 50001LN			
				2 typ	1.85 typ		nim		ASSEUS			
				S.	1.8					350		

★ Designers Drais Sheet characterisation
★ Darlington ## Darlington with speed-up diodo
\*\* | h<sub>th</sub> | @ 1 MHz

# TABLE 13 — Switchmode Power Transistors - STALIGHT

 $V_{CEO} \geqslant 200 \text{ V}$  Devices are listed in descending order of  $V_{CEO(sus)}$ , and  $I_{C}Cont$ 

Daso	stist		1 70 1 4	118	0 10	Resis	stive Switch	hing	2	Amps Verso (sa)
V <sub>CED(sus)</sub>	I <sub>C</sub> Cont	V <sub>CEV</sub>	Device Type	Max N		ts	t <sub>f</sub>		f <sub>T</sub>	Mox Volta M
Volts	Amps	Volts	NPN unless	h <sub>FE</sub> S.1	@ I <sub>C</sub>	μs	μѕ	@ Ic	MHz	Case Case
Min	Max	Min os	otherwise noted	Min/Max	Amp	Max	Max	Amp	Min	JEDEC/MOT
1000	-OT 24 08	1400	BUT36##★	5 min 0	16	4.5 typ	1.7 typ	16	2M6277	TO-197/1
16/19/02-0	12	1400	BUT16##★	5 min	8	2 typ	.8 typ	8	DESTINE !	TO-197/1
850	50	900 900	MJ10050#* MJ10051##*	40 min 40 min	50 50	100 10	35 5	50 50	Sheet chan	MO-040/346 MO-040/346
	25	900 900	MJ10041##* MJ10042#*	25 min 35 min	25 25	10 100	5 35	25 25		—/353 —/353
	20	1200	MJ10025##★	50/600	20	5	1.8	10		TO-204/1
800	10	1400 1500 1500	MJ8505* MJ16018* MJH16018*	7.5 min 7.0 min 7.0 min	1.5 5.0 5.0	2.0 typ 2.0 typ	2 0.9 typ 0.9 typ	5 5.0 5.0		TO-204/1 TO-204/1 TO-218/340
	6	1700	BU209	2.25 min	3	8 typ	.4 typ	4.5	4 typ	TO-204/11
	5	1400 1400	MJ8503* MJE8503*	7.5 min 7.5 min	1 1.0	4 4	2 2	2.5 2.5		TO-204/1 TO-220/221A
	2.5	1400 1400	MJ8501* MJE8501*	7.5 min 7.5 min	0.5 0.5	4 4	2 2	1		TO-204/1 TO-220/221A
750	50	900	MJ10052##★	40 min	50	10	5	50		MO-040/346
	20	1000	MJ10024##*	50/600	20	5	1.8	10		TO-204/1
	8	1500	MJ12005	5 min	5		1	5	4 typ	TO-204/1
	5	1500	MJ12004*	2.5 min	4.5		1	4.5	4 typ	TO-204/1
	4	1500	MJ12003	2.5 min	3		1	3	4 typ	TO-204/1
	2.5	1500 1500	MJ12002★ MJE12007★	1.11 min 1.1 min	2 2		1	2 2	4 typ 4 typ	TO-204/1 TO-220/221A
700	40	1000	BUT35##★	15 min	24	2.8 typ	.65 typ	24		TO-204/197
	20	1000	BUT15##*	15 min	12	1.2 typ	.30 typ	12		TO-204/11
	10	1200	MJ8504*	7.5 min	1.5	4	2	5		TO-204/1
	8	1400	MJ10011#	20 min	4		1	4		TO-204/1
	7	1500	BU208A	2.25 min	4.5	8 typ	.4 typ	4.5	4 typ	TO-204/11
	6	1500	BU500	3 min	4.5	1.2	1	4.5		TO-204/11
	5	1200 1200 1500 1500	MJ8502* MJE8502* BU2080 BU800	7.5 min 7.5 min 2.25 min	1 1 4.5	4 4	2 2 0.6 typ .6 typ	2.5 2.5 4.5 4.5		TO-204/1 TO-220/221A TO-204/1 TO-204/11
	2.5	1200 1200	MJ8500* MJE8500*	7.5 min 7.5 min	0.5 0.5	4 4	2 2	1 1		TO-204/1 TO-220/221A
600	15	700	MJ10014##*	10/250	10	2.5	0.8	10		TO-204/1
550		650	MJ10013##*	10/250	10	2.5	0.8	10		TO-204/1
500	50	750 1000	MJ10016##* BUT34##*	10 min 15 min	40 32	2.5 1.8 typ	.7 typ	20 32		TO-204 Mod/19 TO-204/197
	25	850	BUT14##★	15 min	16	1.3 typ	.3 typ	16		TO204/11
	20	600 800	MJ10009##* MJ13335*	30/300 10/60	10 5	2 4	0.6 0.7	10 10	8**	TO-204/1 TO-204/1
	15	1000 1000 850	MJ16010A* MJH16010A* BUT51P#*	5.0 min 5.0 min 40	15.0 15.0 5	3.0 3.0 1.1 typ	0.4 0.4 .16 typ	10.0 10.0 10		TO-204/1 TO-218/340 TO-218/340
	8	850 1000 1000	BUT50P#* MJ16006A* MJH16006A*	30 5.0 min 5.0 min	2 15.0 15.0	.75 typ 3.0 3.0	.1 typ 0.4 0.4	5 10.0 10.0		TO-218/340 TO-204/1 TO-218/340
	5	1000 1000	MJ16002A* MJH16002A*	5.0 min 5.0 min	15.0 15.0	3.0 3.0	0.3 0.3	3.0 3.0		TO-204/1 TO-218/340
450	100	500 500	MJ10100#★ MJ10101##★	60 min 60 min	100 100	25 3.75	10 1.25	100 100		MO-040/346 MO-040/346
	50	500 500	MJ10044##★ MJ10045#★	50 min 50 min	50.0 50.0	3.8 25	1.3 10	50.0 50.0		—/353 —/353
	30	1000 850 850	BUS98A MJ16020 MJ16022	8 min 5 min 7 min	20 30 30	1.55 typ 1.8 1.5	.2 typ .2 .15	20 20 20		TO-204/197 TO-204/197 TO204/197

(continued)

 $<sup>\</sup>star$  Designers Data Sheet characterization # Darlington ## Darlington with speed-up diode \*\* | h<sub>fe</sub> | @ 1 MHz

 $V_{\text{CEO}} \geqslant 200 \text{ V}$ 

			ssistive Switching	0		Resi	stive Switch	hing		
V <sub>CED(sus)</sub>	I <sub>C</sub> Cont	V <sub>CEV</sub>	Device Type	al		ts	cyTtpoive	a l	oV fr in	Voccoust 1d O
Volts	Amps	Volts	NPN unless	au h <sub>FE</sub>	@ lc	μѕ	μs	@ lc	MHz	
Min	Max	M Min or	otherwise noted	Min/Max	A Amp	Max	Max	Amp	Min	JEDEC/MOT
450	20	650	MJ10008##*	30/300	10	2	0.6	10	8**	TO-204/1
ONE 815	OT 1	750	MJ13101*	8 min	15	3.5	0.5	18 15	888	TO-204/1
11809-0	FF -	850	MJ13334* 2N6837*	10/60	5 15	2.5	0.7	10 15	15	TO-204/1 TO-204/1
A155/058	OT	850	MJ16014*	5 min	20	2.5	0.35	20	13	TO-204/197
220/221A	57	850	MJ16016*	7 min	20	2.2	0.25	20	000	TO-204/197
0-204/1	18	1000	BUS97A	7 min	10	1 2 x	.4	10	(8)	TO-204/197
A153005	15	750	MJ13091*	8 min	10	2.5	0.5	10	18A	TO-204/1
11,2084	DT _	850	2N6836*	10/30	10.0	3.0	0.35	10.0	10	TO-204/1
A1SS1059	OT	850 850	MJ12022★ MJ16010★	5.0 min 5 min	15.0 15	1.2 typ	0.1 typ 0.2 typ	10.0	080	TO-204/1 TO-204/1
2-204V1 08V890		850	MJ16012*	7 min	15	0.9 typ	0.15 typ	10	850	TO-204/1
14.05-6		850	MJH16010*	5.0 min	15.0	1.2	0.2	10.0	88	TO-218/340
A11331059	OT .	850 1000	MJH16012* BUS48A*	7.0 min 8 min	15.0	0.9 1.3 typ	0.15 .2 typ	10.0	(89)	TO-218/340 TO-204/19
ATSSVOSS	01	1000	BUS48AP*	8 min	8	1.3 typ	.2 typ	10	700	TO-218/340
08/88/46	9	1000	BUS47A*	7 min	5	1 typ	.2 typ	5	SUN	TO-204/11
ATSSUES	-01		BUS47AP★	7 min	6	1 typ	.2 typ	6	080	TO218/340
ATSSVSS	OT 8	750	MJ13081*	8 min	5	1.5	0.5	18 5	005	TO-204/1
FITTER	or	850 850	2N6835* MJ12021*	7.5/3.0 5.0 min	5.0 8.0	2.5	0.25 0.1 typ	5.0 8.0	10	TO-204/1 TO-204/1
08/89 €		850	MJ16006*	5 min	8	2.5	0.1 typ	5		TO-204/1
A 100,008	OT	850	MJ16008*	7 min	8	2.2	0.25	5	000	TO-204/1
\$1.55/055	OT	850 850	MJH16006★ MJH16008★	5.0 min 7.0 min	8.0 8.0	2.5	0.25 0.25	5.0 5.0	ann.	TO-218/340 TO-218/340
67,480-40	7	030	BU522B#	250 min	2.5	2.2	0.25	5.0	7.5	TO-220/221A
20/22/1A	5	750	MJ13071*	230 min	3	1.5	0.5	3	7.5	
1/1/05/	-	750	MJE13071*	8 min	3	1.5	0.5	3	000	TO-204/1 TO-220/221A
-040/346	OM.	850	2N6834*	10/30	3.0	2.7	0.35	3.0	15	TO-204/1
BINDOM A	10-2	850 850	MJ12020* MJ16002*	5.0 min 5 min	5.0	3	0.13 typ 0.3	3.0	450	TO-204/1
2 204/1	I I	850	MJ16002×	8 min	3	2.7	0.35	3	450	TO-204/1 TO-204/1
0-20 Uf		850	MJE16002*	5 min	5	3	0.3	3	683	TO-220/221A
17700-0		850 850	MJE16004* MJH16002*	7 min	5.0	2.7	0.35	3	daa	TO-220/221A
19-08-6	ir I	850	MJH16002*	5.0 min 7.0 min	5.0	3.0	0.30	3.0	375	TO-218/340 TO-218/340
018340	2	1000	BUX85	81	a n	3.5	1.4	1 80		TO-220/221A
425	7	101	BU522A#	250 min	2.5	10 EX08   ×	w 4x 8080 t	LM	7.5	TO-220/221A
400	56	600	BUT33##★	9	No.	0.4	0.4	00	903	
400	50	650	MJ10015##*	20 min	36 40	2 typ 2.5	.8 typ	36	700	TO-204/197 TO-204 Mod/19
A125/055	40	600	MJ10013##*	50/600	10	2.5	0.9	20	(130	TO-204 Mod/19
A138/088	30	850	BUS98*	8 min	20	1.55 typ	.2 typ	20	100	TO-204/197
PS04/1	28	600	BUT13##*	20 min	18	THE PASSET OF TH	182011	18	375	8
06/884	20	450	BUV24*	8 min	12	1.1 typ	.3 typ	MISC T.	OP o	TO-204/11
A I SSVDES	OT	500	MJ10001#*	40/400	10	3	.9 1.8	12	10**	TO-204/197 TO-204/1
A195/098	OT	500	MJ10005#★	40/400	10	1.5	0.5	10	10**	TO-204/1
757/103	OT	500 650	MJ13333* MJ13100*	10/60	5	3.5	0.7	10	402	TO-204/1
174-054	18	850	BUS97	8 min	15	11 53 20 11	0.35	15	000	TO-204/1
T PMC-	15	850	BUS48*	7 min 8 min	12	2	.4	12	00%	TO-204/197
14054	15	850	BUS48P*	8 min	10	1.3 typ 1.3 typ	.2 typ .2 typ	10	760	TO-204/11 TO-218/340
03/86-6	F L	850	2N6547	6/30	10	4	.7	10	6 to 24	TO-204/1
15002-6	T   10	650 650	MJ13090* 2N6678	8 min 8 min	10	2.5	0.5 0.5	10 15	3	TO-204/1
11905-0 A FORMAN	OT 12	700	MJE13009*	6/30	8	3	0.5	8	3 4**	TO-204/1 TO-220/221A
220/321A 0-204/	10	950	MJ12010	4.2 min	5	DOM:	1	5	6 typ	TO-204/1
114054		550	MJ10012#	100/2k	6	6	15	15	6	TO-204/1
A135/056	-or	500	MJ10003#★	30/300	5	2.5	Eladore	5	10**	TO-204/1
220/221A	OT	500 450	MJ10007##* MJ13015*	30/300 8/20	5 5	1.1	0.25	5	10**	TO-204/1
	-07	100	BU323AP	0/20	0	4	0.5	0	100	TO-204/1

<sup>\*</sup> Designers Data Sheet characterization # Darlington ## Da

TABLE 13 — Switchmode Power Transistors (continued) and rework observatives — EF BLEAT

 $V_{\text{CEO}} \geqslant 200 \text{ V}$ 

			tsistive Switching			Resi	stive Swite	ching		
V <sub>CED(sus)</sub>	I <sub>C</sub> Cont	V <sub>CEV</sub>	Device Type	al		ts	gy/Tteoive	id i	doV fr th	Vot to Co
Volts	Amps	Volts	NPN unless	eu hee	@ lc	μѕ	us /	@ lc	oV MHz	
Min	Max	M Min	otherwise noted	Min/Max	Amp	Max	Max	Amp	Min	JEDEC/MOT
400	9	8 850	BUS47*	7 min	6 0	1 typ	.2 tvp	6	038	TO-204/11
204/1		850	BUS47P*	₹ 7 min	5	1 typ	.2 typ	6	750	TO-218/340
	8	850	2N6545*	7/35	5	4	PAREEL	5	6	TO-204/1
	OT 1	800	MJE5742#	200/400	4	8 typ	2 typ	6	120	TO-220/221A
	CT .	700 650	MJE13007* MJ13080*	6/30 8 min	5	1.5	0.7	5	08 4	TO-220/221A TO-204/1
-04/197	OT	450	MJ6503-PNP*	\$15 min	2 1	2	0.5	UB 4 1	1000	TO-204/1
DACS-0	IT.	450	MJE5852-PNP*	15 min	2	2	0.5	4	750	TO-220/221A
	6	900	BU326A	30 typ	0 6. 10	3.5	.3 typ	2.5	6 850	TO-204/11
100S-0	5	850	BUS46P*	7 min	3	.4 typ	.175 typ	3	000	TO-220/221A
1/4/08/0	7	850 850	2N6543* MJ4401*	7/35 7/35	3	4 4	0.8	3	6	TO-204/1
	OT	650	MJ13070*	8 min	3	1.5	0.5	3	000	TO-66/80 TO-204/1
	OT	650	MJE13070*	8 min	8 15 N	1.5	0.5	3	850	TO-220/221A
	or 4	700	MJE13005*	6/30	3	3	0.7	3	4	TO-220/221A
-204011	97	700	MJ4381*	8/40	2	4	0.9	2	300 4	TO-66/80
219/340	3	850	BUS45P	6 min	2	.4 typ	.175 typ	UE 2	-	TO-220/221A
MM05-0	2	800	BUX84	1.5	8 1	3.5	1.4	Lat 1	750	TO-220/221A
0-204/1 0-204/1	1.5	700	MJE13003* MJ4361*	5/25 5/25	.8 1 ni	0.34	0.7	Lav	5 4	TO-126/77R TO-66/80
	- 1	500	TIP50*	30/150	0.3	5.0	* DUUE	1.86	0.00	
	1	500	MJE5732-PNP	30/150	0.3	2 typ	.18 typ	3	10	TO-220/221A TO-220/221A
	OT 0.5	400	MJ4647-PNP	20 min	8 0.5	0.72*	*800081H	0.05	128 40	TO-39/79
375	OT 7	7.5	BU522#	250 min	2.5	250 m	8228#	BUE	7.5	TO-220/221A
	6	800	BU326	30 typ	.6	3.5	.3 typ	2.5	6 75	TO-204/11
350	100	500	MJ10102##*	60 min	100	3.75	1.25	100	750	MO-040/346
	40	450	MJ10022##*	50/600	a 10 m	0.2.5	0.9	20	188	TO-204 Mod/19
	20	450	MJ10000#*	40/400	10	3	1.8	10	10**	TO-204/1
	OT	450	MJ10004##*	40/400	10	1.5	0.5	10	10**	TO-204/1
	oi .	450	MJ13332*	10/60	5	4	0.7	10	100	TO-204/1
	OT 15	550 375	2N6677 2N6251	8 min 6/50	15	3.5	0.5	15	2.5	TO-204/1 TO-204/1
20/221A	OT 10		BU323P	150 min	6	15	15	6	ohne I	TO-218/340
W122/02	01.1	450	MJ10002#★	30/300	5	2.5	1	5	10**	TO-204/1
	-OT	450 400	MJ10006##* MJ13014*	30/300	S 5 m		0.5	ua 5	10**	TO-204/1
	OT 8			8/20	5	2	0.5	5	100 -	TO-204/1
e i washi s	E 0.T	700	2N6308 MJE5741#	12/60 200/400	3 4	1.6 8 typ	0.4 2 typ	5	5	TO-204/1 TO-220/221A
	IS OT	400	MJE5851-PNP	15 min	2	2	0.5	4	000	TO-220/221A
	5	450	2N6499	10/75	2.5	1.8	0.8	2.5	5	TO-220/221A
	3	375	2N5840	10/50	2	3	1.5	2	5	TO-204/1
	2	400	2N6213-PNP	10/100	. 1	2.5	0.6	1	4	TO-66/80
	1	450	TIP49*	30/150	.3 0	2 typ	.18 typ	.3	08 10	TO-220/221A
1,403-0	II	101	MJE5731-PNP	30/150	0 3.	40/40	# * E000	LNA	08 10	TO-220/221A
325	30	400	BUV23*	8 min	16	1.8	.4	16	8 50	TO-204/197
	15	400	BUX13*	8 min	8	2.5	.8	8	8	TO-204/11
20411	10	400	BUX43	8 min	5	2.2	.9	1	8	TO-204/11
2:8/340	OT 5	700	MJ3030	3.75 min	3	1 8 mm	*4818	3	088	TO-204/1
200	T 45	350	2N6235	25/125	1 1	3.5	0.5	1 214	20	TO-66/80
300	15	650 450	2N6546* 2N6676	6/30 8 min	10 15	2.5	0.7 0.5	10 15	6 to 24	TO-204/1 TO-204/1
A122021A	T 12	600	MJE13008*	6/30	8	3	0.7	W 8	4**	TO-220/221A
	8	650	2N6544*	7/35	3 5 m	7	12016	LM 5	6 350	TO-204/1
	1	600	2N6307	15/75	3 %	1.0	0.4	3	5 5	TO-204/1
	-	600	MJE13006* MJE5740	6/30 200/400	5 4	8 typ	0.7 2 typ	5	4 500	TO-220/221A TO-220/221A
	TT I	350	MJE5850-PNP*	15 min	2	8 typ	0.5	4	450	TO-220/221A
300	7	275	2N6077	12/70	1.2	2.8	0.3	1.2	7	TO-66/80

<sup>\*</sup> Designers Data Sheet characterization # Darlington ## Da

**TABLE 13** — Switchmode Power Transistors (continued)

 $V_{CEO} \geqslant 200 \text{ V}$ 

						Resi	stive Switch	hing		
V <sub>CED(sus)</sub>	I <sub>C</sub> Cont	V <sub>CEV</sub>	Device Type			ts	tf		fT	
Volts	Amps	Volts	NPN unless	hee	@ lc	μs	μs	@ 10	MHz	Case
Min	Max	Min	otherwise noted	Min/Max	Amp	Max	Max	Amp	Min	JEDEC/MOT
300	5	650 650 400	2N6542* MJ4400* 2N6498	7/35 7/35 10/75	3 3 2.5	4 4 1.8	0.8 0.8 0.8	3 3 2.5	6 6 5	TO-204/1 TO-66/80 TO-220/221A
	4	600 600	MJE13004* MJ4380*	6/30 8/40	3 2	3 4	0.7 0.9	3 2	4 4	TO-220/221A TO-66/80
	2	500 500 350	2N3585 2N6422-PNP 2N6212-PNP	25/100 25/100 10/100	1 1 1	4 4 2.5	3 3 0.6	1 1 1	10 10 4	TO-66/80 TO-66/80 TO-66/80
	1.5	600 600	MJE13002* MJ4360*	5/25 5/25	1	4 4	0.7 0.7	1	5 4	TI-126/77R TO-66/80
	1	300 400	2N5345-PNP TIP48* MJE5730-PNP	25/100 30/150 30/150	0.5 .3 .3	0.6 2 typ	0.1 .18 typ	0.5 .3	60 10 10	TO-66/80 TO-220/221A TO-220/221A
	0.5	300	MJ4646-PNP	20 min	0.5	0.72*		0.05	40	TO-39/79
275	15	300	2N6250	8/50	10	3.5	1	10	2.5	TO-204/1
	7	275	2N6078	12/70	1.2	2.8	0.3	1.2	7	TO-66/80
	5	275	2N6234	25/125	1	3.5	0.5	1	20	TO-66/80
	3	300	2N5839	10/50	2	3.75	1.5	2	5	TO-204/1
250	200	300 300	MJ10200#★ MJ10201##★	90 min 90 min	200 200	20 4	8	20 200		MO-040/346 MO-040/346
	100	300 300	MJ10047##★ MJ10048#★	75 min 75 min	100.0 100.0	4.0 2.0	1.0	100 100		—/353 —/353
	60	350	MJ10021##*	25 min	30	3.5	0.5	30		TO-204 Mod/19
	40	350 300	BUS52* BUV22	15 min 10 min	40 20	2 1.1	.3 .35	40 20	8	TO-204/197 TO-204/197
	20	450 300	MJ13331* BUV12*	8/40 10 min	10 10	3.5 1.5	0.7 .5	10 10	5/40 8	TO-204/1 TO204/11
	15	250 250	MJ11021#PNP MJ11022#	100 min 100 min	15 15				3# 3#	TO-204/1 TO-204/1
	12	300	BUX42*	8 min	6	2	.4	6	8	TO-204/11
	8	500 400	2N6306 MJ6502-PNP*	15/75 15 min	3 2	1.6	0.4 0.5	3 4	5	TO-204/1 TO-204/1
	5	500 350	MJ3029 2N6497	30 min 10/75	0.4 2.5	1.8	1 0.8	3 2.5	5	TO-204/11 TO-220/221A
	3	275	2N5838	10/50	2	3	1.5	3	5	TO-204/11
	2	375 375	2N3584 2N6421-PNP	25/100 25/100	1 1	4 4	3 3	1	10 10	TO-66/80 TO-66/80
	1	250 350	2N5344-PNP TIP47*	25/100 30/150	0.5 .3	0.6 2 typ	0.1 .18 typ	0.5 .3	60 10	TO-66/80 TO-220/221A
225	2	275	2N6211	10/100	1	2.5	0.6	1	20	TO-66/80
200	200	300	MJ10202##★	90 min	200	4	1	200		MO-040/346
	60	300	MJ10020##★	25 min	30	3.5	0.5	30		TO-204 Mod/19
	50	300	BUS51★	15 min	50	2	.3	5		TO-204/197
	40	250	BUV21*	10 min	25	1.8	.4	25	8	TO-204/197
	20	250 400	BUV11* MJ13330*	10 min 8/40	12 10	1.8 3.5	0.7	12 10	8 5/40	TO-204/11 TO-204/11
	15	250 225 200 200	BUX41 * 2N6249 MJ11019#PNP MJ11020#	8 min 10/50 100 min 100 min	8 10 15 15	1.5 3.5	.4	8 10	8 2.5 3# 3#	TO-204/11 TO-204/11 TO-204/1 TO-204/1
	3	250	BUY49P	30 min	0.5				25	TO-126/77
	2	200	2N5052	25/100	0.75	3.5	1.2	0.75	10	TO-66/80
	0.5	200	MJ4645-PNP	20 min	0.5	0.72*		0.05	40	TO-39/79

 <sup>★</sup> Designers Data Sheet characterization
 # Darlington ## Darlington with speed-up diode

		stivo Switc							
						Device Type		le Gom	
			61/						Votes
			Max		xsld/niM	otherwise noted	niNi	Natr	
TWOS-OT I		8.0			7/35	2N8502+	698		
	3					+0084UM			
		8.0				2049963	400		
			8			* 900C1S/PHT		1 4	
	2		. A		06/40	*OBCALAS	000		ł
			- A-		oones oones				
			2.5		10/100	ZM6212-PMP			
			- b	1					
		1.0				2ME348-PNP	085		
					38/150	THP48.4 NJES730-PNP			
					30/190	SELVICAC-PRIP			
								0.5	
						2N6220			
						2146078	578		
TO-66/80						2M6234		8	
						#4/10200# ± ± 1	300	002	
			, A			SENTENCE OF SENTEN			
	100			190.0	75 min 37	**85001UM			
	30					***12001LM	080		
						+52308			
					nim Gi				
						MATERBALL	480		
		.5				BUV124			
							260	1.5	
	8				nim 8	BUNGSW		12	
		0.4	1.6					1 1	
	-			2	nisn 01	W/8805-5Mb/H		-	
					30 min 1075	200000	500 350	9	
						803848	275		1
		1.5				SHORM	375	1 2	
						2N6421-PMP			
	0.5	1.0				2355344-2412		1	
						192028			
						F198995			
	008					W410202 mm + 1			200
						\$4.40020 at k	390	.00	
							0.005		
			1.8					0.5	
		8.				2007118		20	
							400		
				8		enacus.	230		
						20/82/0	225		
					100 min 100 min	MJ410103-PMP MJ41020-	200		
						807499			
		5.1				2007007			
								1.0	

<sup>#</sup> Dresigners Data Sitest characterization.
# Dresignor # # Datagon with speed-up diode \* tot

4 AMPERE

05 VOCTS 25 WATTS — 2N3064 25 WATTS — 2N3064 SECTION POWER MEM SILICON TRANSPORCE

... designed for general purpose switching and amplifier applications.

₱ Excellent Safe Operating Area

DC Current Gain Specified to 3.0 Amperes
 Complement to PNP Type 2N6049 or 2N4912

The following power transistor data sheets are arranged in alphanumeric sequence except in such instances where a particular data sheet may contain information applying to more than one transistor — e.g. 2N4398, 2N4399, 2N5745. To determine if a particular device type is covered by a data sheet in this

section, please refer to the alphanumeric listing of the Index and Cross Reference on page1-2. **Data Sheets** 

Peak

Base Current

Total Device Dissipation 9 To = 2

Devate above 26°C

Operate above 26°C

Terranal Control of the Control

\*\*Addition to JEDEC Registered Date
THERMAL CHARACTERISTICS

Characteristic Symbol 282094A 2M3094
Themnal Residence, Junction to Case Residence 233 7.0

| No. | No.



## MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for general purpose switching and amplifier applications.

- Excellent Safe Operating Area
- DC Current Gain Specified to 3.0 Amperes
- Complement to PNP Type 2N6049 or 2N4912

tor data sheets are

## \*MAXIMUM RATINGS

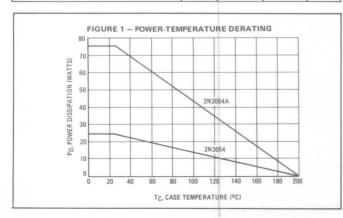
			DO VEDE	
Rating	Symbol	2N3054A	2N3054	Unit
Collector-Emitter Voltage	VCEO	105	5 611611	Vdc
Collector-Emitter Voltage (RBE = 100 $\Omega$ )	VCER	9 раг-	oii enim	Vdc
Collector-Base Voltage	Vсв	81/11/19	sheet o	Vdc
Emitter-Base Voltage	VEB	30.07	.0	Vdc
Collector Current — Continuous Peak	IC		0.	Adc
Base Current	IB	2	.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	75 0.43	25 0.143	Watts W/OC
Operating and Storage Junction, Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

\*Indicates JEDEC Registered Data

\*\*Addition to JEDEC Registered Data

## THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3054A	2N3054	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	2.33	7.0	°C/W



## 4 AMPERE

## POWER TRANSISTORS NPN SILICON

55 VOLTS 25 WATTS - 2N3054 75 WATTS - 2N3054A



STYLE 1:
PIN 1: BASE
2. EMITTER
CASE: COLLECTOR
P
B
C
C
SEATING PLANE
F
J
T

1			1	
			S	
	MILLI	METERS	IN	CHES
DIM	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
Н	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590

T 2.47 2.07 0.050 0.590

All JEDEC Dimensions and and Notes Apply.

CASE 80-02

TO-66

3

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				0.2
Collector-Emitter Sustaining Voltage (1) (IC = 100 mAdc, I <sub>B</sub> = 0)	V <sub>CEO(sus)</sub>	55		Vdc
Collector-Emitter Sustaining Voltage (1) (IC = 100 mAdc, R <sub>BE</sub> = 100 Ω)	VCER(sus)	60		Vdc
Collector Cutoff Current (Mg = 30 Vdc, IB = 0)	ICEO	983	500	μAdc
Collector Cutoff Current (VCE = 90 Vdc, VBE (off) = 1.5 Vdc) (VCE = 90 Vdc, VBE (off) = 1.5 Vdc, TC = 150°C)	ICEX J.A	8,0 0.0	6.0	mAdc <sub>0.0</sub>
Emitter Cutoff Current (VBE = 7.0 Vdc, I <sub>C</sub> = 0)	<sup>I</sup> EBO	_	1.0	mAdc

## \*ON CHARACTERISTICS (1)

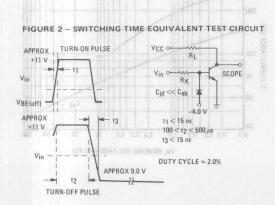
DC Current Gain (I <sub>C</sub> = 0,5 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	hFE d 0 m 0.1	25 5.0	150	10.7 0.0 10.0 10.0
Collector-Emitter Saturation Voltage (IC = 500 mAde, IB = 50 mAde)	VCE (sat)	Langua -	1.0	Vdc
Base-Emitter On Voltage (I $_{C}$ = 500 mAdc, V $_{CE}$ = 4.0 Vdc)	V <sub>BE</sub> (on)	nany hatel weight	1.7	Vdc

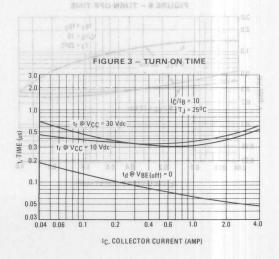
## DYNAMIC CHARACTERISTICS on a color of teleps your of

Current-Gain-Bandwidth Product	fT	de la constitución de la constit	BONDING W THERMAL L	MHz
*Small-Signal Current Gain (IC = 100 mAdc, VCE = 4.0 Vdc, f = 1.0 kHz)	hfe us	8 25 GT	180	2.0
*Common-Emitter Cutoff Frequency (IC = 100 mAdc, VCE = 4.0 Vdc)	fhfe 2710	30	VCE, COLLECTOR	kHz

\*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width  $\leqslant$  300  $\mu$ s, Duty Cycle  $\leqslant$  2.0%





3

FIGURE 4 - THERMAL RESPONSE

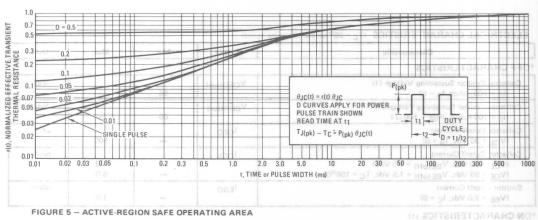
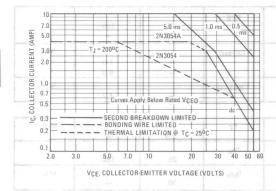


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 200^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 6 - TURN-OFF TIME

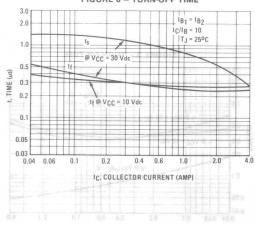
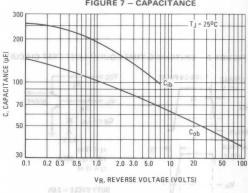


FIGURE 7 - CAPACITANCE

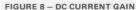




0.01

0.02 0.04





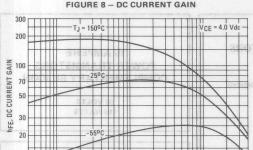
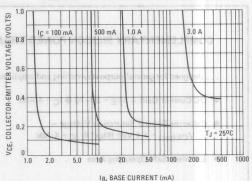
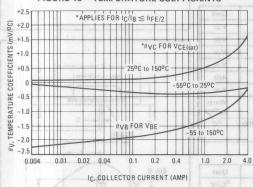


FIGURE 9 - COLLECTOR SATURATION REGION



## FIGURE 10 - TEMPERATURE COEFFICIENTS

IC, COLLECTOR CURRENT (AMP)



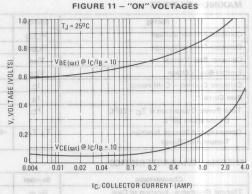


FIGURE 12 - COLLECTOR CUT-OFF REGION

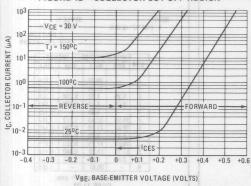
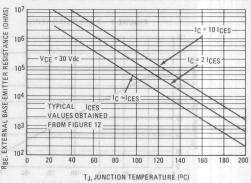


FIGURE 13 - EFFECTS OF BASE-EMITTER RESISTANCE





PIGURE 8 - DC CURRENT GAIN

FIGURES - COLLECTOR SATURATION REGION

## COMPLEMENTARY SILICON POWER TRANSISTORS

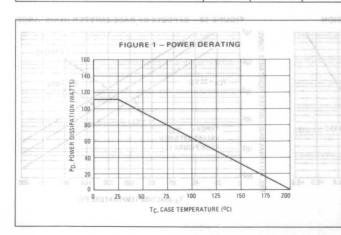
- . . . designed for general-purpose switching and amplifier applications.
- DC Current Gain hFE = 20-70 @ IC = 4 Adc
- Collector-Emitter Saturation Voltage VCE(sat) = 1.1 Vdc (Max) @ IC = 4 Adc
- Excellent Safe Operating Area



Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Emitter Voltage	VCER	70	Vdc
Collector-Base Voltage	VCB	100	Vdc
Emitter-Base Voltage	VEB	7	Vdc
Collector Current — Continuous	lc	15	Adc
Base Current	IB	7	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	115 0.657	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	3008 oC

## THERMAL CHARACTERISTICS

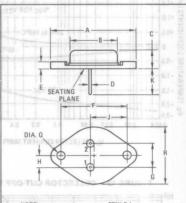
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.52	°C/W



15 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

> 60 VOLTS 115 WATTS





" IS DIA.		2.	BASE	
MILLI	METERS	INC	HES	
MIN	MAX	MIN	MAX	1
	39.37	-1901	1.550	
	21.08	-	0.830	1.
6.35	7.62	0.250	0.300	
0.99	1.09	0.039	0.043	
-	3.43	-	0.135	3
29.90	30.40	1.177	1.197	1
10.67	11.18	0.420	0.440	
5.33	5.59	0.210	0.220	
16.64	17.15	0.655	0.675	
11.18	12.19	0.440	0.480	
3.84	4.09	0.151	0.161	
-	26.67	-	1.050	
	MILLI MIN	MILLIMETERS MIN MAX - 39.37 - 21.08 6.35 7.62 0.99 1.09 - 3.43 29.90 30.40 10.67 11.18 5.33 5.59 16.64 17.15 11.18 12.19 11.18 12.19 3.84 4.09	2 CASE  MILLIMETERS INC MIN MAX MIN  - 39.37 21.08 6.35 7.62 0.250 0.99 1.09 0.039 3.43 29.90 30.40 1.177 10.67 11.18 0.420 5.33 5.59 0.210 16.64 17.15 0.655 11.18 12.19 0.440 3.84 4.09 0.151	MILLIMETERS   INCHES     MIN   MAX   MIN   MIN

## ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		307	35031 -	7
Collector-Emitter Sustaining Voltage (1) (IC = 200 mAdc, Ig = 0)	VCEO(sus)	60	- 30°E	Vdc
Collector-Emitter Sustaining Voltage (1) (IC = 200 mAdc, RBE = 100 Ohms)	VCER(sus)	70	The phase	Vdc
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0)	ICEO		0.7	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 100 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 100 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEX		1.0 5.0	mAdc
Emitter Cutoff Current (VBE = 7.0 Vdc, IC = 0)	IEBO		5.0	mAdc

## \*ON CHARACTERISTICS (1)

DC Current Gain (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)	hFE	20 5.0	70 -	-
Collector-Emitter Saturation Voltage	V <sub>CE(sat)</sub>			Vdc
(I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 400 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 3.3 Adc)	20042 - 71		1.1 3.0	2.0
Base-Emitter On Voltage (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	V <sub>BE(on)</sub>	A B.	1.5	Vdc

## SECOND BREAKDOWN

Second Breakdown Collector Current with Base Forward Biased	I <sub>s</sub> /b	2.87	Adc
(V <sub>CE</sub> = 40 Vdc, t = 1.0 s; Nonrepetitive)			

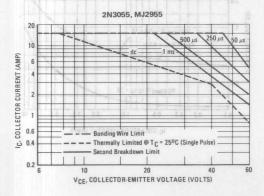
## DYNAMIC CHARACTERISTICS

Current Gain — Bandwidth Product	fT			MHz
(I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)		2.5		
*Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 kHz)	hfe ook of	00e 15 00s	120	61 62
*Small-Signal Current Gain Cutoff Frequency (V <sub>CF</sub> = 4.0 Vdc, I <sub>C</sub> = 1.0 Adc, f = 1.0 kHz)	fhfe	10	Muos sove '81	kHz

<sup>\*</sup> Indicates Within JEDEC Registration. (2N3055)

(1) Pulse Test: Pulse Width  $\leq 300~\mu\text{s}$  , Duty Cycle  $\leq 2.0\%$ 

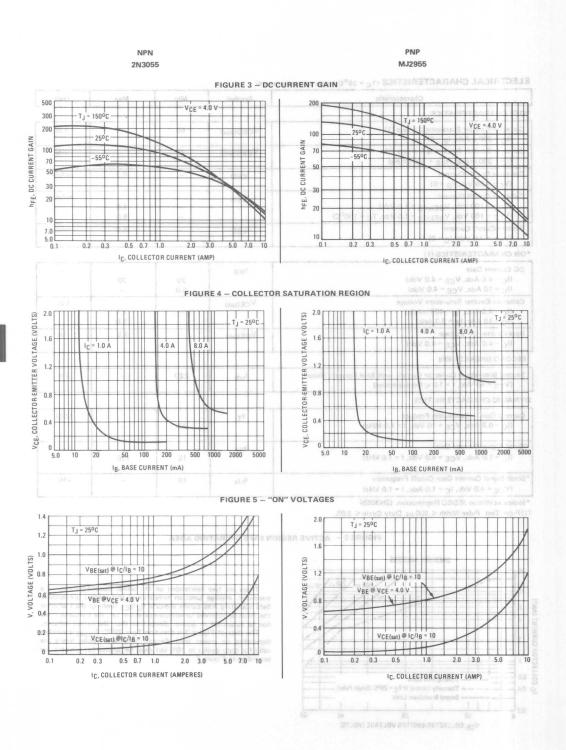
FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C \cdot V_C E$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 2 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable

The data of Figure 2 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 1.







## COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

... PowerBase complementary transistors designed for high power audio, stepping motor and other linear applications. These devices can also be used in power switching circuits such as relay or solenoid drivers, dc-to-dc converters, inverters, or for inductive loads requiring higher safe operating area than the 2N3055 and MJ2955.

- Current-Gain Bandwidth-Product @ IC = 1.0 Adc
  - fT = 0.8 MHz (Min) NPN
    - = 2.2 MHz (Min) PNP
- Safe Operating Area Rated to 60 V and 120 V. Respectively

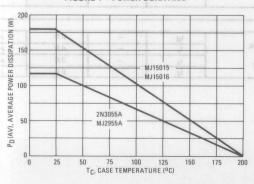
*MAXIMUM RATINGS		Asst		
Rating	Symbol	2N3055A MJ2955A	MJ15015 MJ15016	Unit
Collector-Emitter Voltage	VCEO	60	120	Vdc
Collector-Base Voltage	VCBO	100	200	Vdc
Collector-Emitter Voltage Base Reversed Biased	VCEV	100	200	Vdc
Emitter-Base Voltage	VEBO	7.0		Vdc
Collector Current — Continuous	or Ic	1	5	Adc
Base Current	os IB	7	7.0	
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	115 0.65	180 1.03	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Max	Unit
Thermal Resistance, Junction to Case	θJC	1.52	0.98	°C/W

\*Indicates JEDEC Registered Data (2N3055A)

## FIGURE 1 - POWER DERATING

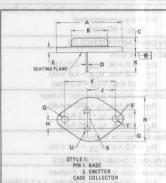


## 15 AMPERE

## COMPLEMENTARY SILICON **POWER TRANSISTORS**

60, 120 VOLTS 115, 180 WATTS





DTES:

1. ALL RULES AND NOTES ASSOCIATED WITH
1. ALL RULES AND NOTES ASSOCIATED WITH
2. 001-02 0.050 LTET. NEW STANDARD 010-10.
2. 001-02 0.050 LTET. NEW STANDARD 010-10.
4. DIAMETER VANO SURFACE WARE DATUMS.
5. POSITIONAL TOLERANCE FOR HOLE 0.

(Image: 100.050 LTET. NEW STANDARD 001-03.
4. DIAMETER VANO SURFACE WARE DATUMS.
5. POSITIONAL TOLERANCE FOR HOLE 0.

(Image: 100.050 LTET. NEW STANDARD 001-03.

(Image: 10



TO-204AA

M12955A - W115916





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COMPLEMENTARY SILICON

COMPLEMENTARY SILICON

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted).

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS (1)		55 and MJ2955	than the 2N30	sees onliterance	alaz verlairi
*Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N3055A, MJ2955A MJ15015, MJ15016	VCEO(sus)	60 120	- Vbna8- nie9-:	Vdc
Collector Cutoff Current (VCE = 30 Vdc, VBE(off) = 0 Vdc) (VCE = 60 Vdc, VBE(off) = 0 Vdc)	2N3055A, MJ2955A MJ15015, MJ15016	ICEO		0.8 MHz (Min) 2.2 M 7.0 Min) 1.0	mAdc
*Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc)	2N3055A, MJ2955A MJ15015, MJ15016	ICEV	-	5.0 1.0	mAdc
Collector Cutoff Current (V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N3055A, MJ2955A MJ15015, MJ15016	ICEV		30 6.0	mAdc
*Emitter Cutoff Current (V <sub>EB</sub> = 7.0 Vdc, I <sub>C</sub> = 0)	2N3055A, MJ2955A MJ15015, MJ15016	I <sub>EBO</sub>	-	5.0 0.2	mAdc

*SECOND BREAKDOWN	THE STORTES	Vocezew I	laam ye	Bariag	
Second Breakdown Collector Current with	Base Forward Biased	Is/b	DEDA	AGREGA	Adc
(t = 0.5 s non-repetitive)	2N3055A, MJ2955A	001	080 V 1.95	_ sgeti	V neu El-notos la
(V <sub>CE</sub> = 60 Vdc)	MJ15015, MJ15016	007	VEDV 3.0	Voltage <del>S</del> ate	stim i-rotaels
*ON CHARACTERISTICS (1)					Revented Big
DC Current Gain	357	hFE	Olevin	808	DA PERMITTE
(IC = 4.0 Adc, VCE = 2.0 Vdc)			10	20070 mod -	Nector Current
$(I_C = 4.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc})$ $(I_C = 4.0 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc})$		17	20	70	See Curre
(IC = 10 Adc, VCF = 4.0 Vdc)		als I	5.0	nation Office = 2	aid soverd law

(IC - 4.0 Adc, VCF - 2.0 Vdc)			the second second second	10	70	The same of the same of
(IC = 4.0 Adc, VCE = 4.0 Vdc)			7	20	70	Curre
(IC = 10 Adc, VCE = 4.0 Vdc)			1 811	5.0	nation Office 2 PC	al Device Diss
Collector-Emitter Saturation Voltage	3p/M	1.03	VCE(sat)		15°C	vocVdc ⊨0
(I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 400 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 3.3 Adc)	30		or 69 -	ONE OF T	2.0	erating and Str Temper sture
(I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 7.0 Adc)				-	5.0	
Base-Emitter On Voltage			VBE(on)	0.7	1.8 AHA	Vdc
(IC = 4.0 Adc, VCE = 4.0 Vdc)			Max	Sympol	practeristic	ri O
*DYNAMIC CHARACTERISTICS	M/3o	36.0	1.62	3L <sup>0</sup>	ce, Junction to Care	nergize R bams
	(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)  Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 400 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 3.3 Adc) (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 7.0 Adc)  Base-Emitter On Voltage (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	(IC = 4.0 Adc, VCE = 4.0 Vdc) (IC = 10 Adc, VCE = 4.0 Vdc)  Collector-Emitter Saturation Voltage (IC = 4.0 Adc, IB = 400 mAdc) (IC = 10 Adc, IB = 3.3 Adc) (IC = 15 Adc, IB = 7.0 Adc)  Base-Emitter On Voltage (IC = 4.0 Adc, VCE = 4.0 Vdc)	(IC = 4.0 Adc, VCE = 4.0 Vdc) (IC = 10 Adc, VCE = 4.0 Vdc)  Collector-Emitter Saturation Voltage (IC = 4.0 Adc, IB = 400 mAdc) (IC = 10 Adc, IB = 3.3 Adc) (IC = 15 Adc, IB = 7.0 Adc)  Base-Emitter On Voltage (IC = 4.0 Adc, VCE = 4.0 Vdc)	(IC = 4.0 Adc, VCE = 4.0 Vdc) (IC = 10 Adc, VCE = 4.0 Vdc)  Collector-Emitter Saturation Voltage (IC = 4.0 Adc, IB = 4.00 mAdc) (IC = 10 Adc, IB = 3.3 Adc) (IC = 15 Adc, IB = 7.0 Adc)  Base-Emitter On Voltage (IC = 4.0 Adc, VCE = 4.0 Vdc)	(IC = 4.0 Adc, VCE = 4.0 Vdc) (IC = 10 Adc, VCE = 4.0 Vdc)  Collector-Emitter Saturation Voltage (IC = 4.0 Adc, IB = 400 mAdc) (IC = 10 Adc, IB = 3.3 Adc) (IC = 15 Adc, IB = 7.0 Adc)  Base-Emitter On Voltage (IC = 4.0 Adc, VCE = 4.0 Vdc)	Collector-Emitter Saturation Voltage   Collector Land Collector

_	DITEATIO OFFAITAGIETIOTICS		4		April 1997		
	Current-Gain-Bandwidth Product	2N3055A,	MJ15015	fT	0.8	6.0	MHz
	(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 MHz)	MJ2955A,	MJ15016		2.2	18	
	Output Capacitance	1		Cob	60	600	pF
	$(V_{CB} = 10 \text{ Vdc}, I_{E} = 0, f = 1.0 \text{ MHz})$			ERATHNG	B 1 - POWER D	FIGUI	

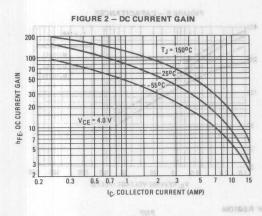
\*SWITCHING CHARACTERISTICS (2N3055A only)

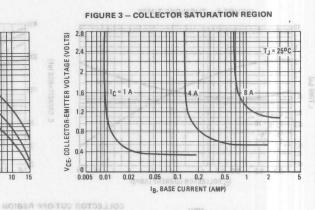
RESISTIVE LOAD	6- 070.0 25.0 E/g				3
Delay Time	$(V_{CC} = 30 \text{ Vdc}, I_{C} = 4.0 \text{ Adc}, I_{B1} = I_{B2} = 0.4 \text{ Adc}, \tau_{p} = 25  \mu\text{s} \text{ Duty Cycle} \leqslant 2\%)$	t <sub>d</sub>		0.5	μѕ
Rise Time		t <sub>r</sub>		4.0	μs
Storage Time		ts	- /	3.0	μѕ
Fall Time		t <sub>f</sub>		6.0	μѕ

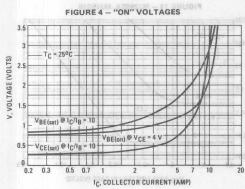
(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.
\*Indicates JEDEC Registered Data (2N3055A)

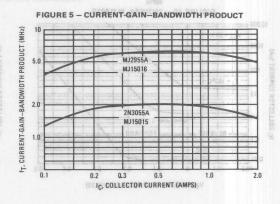
CASE 1-04 TO-204AA 20 26 50 75 708 128 150 (75 20 T) 70 128 150 (75 20 T)

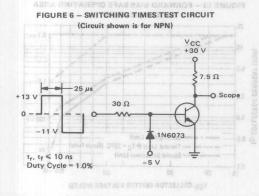
3

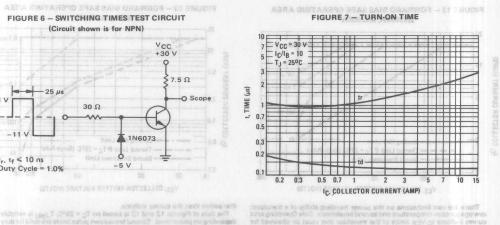


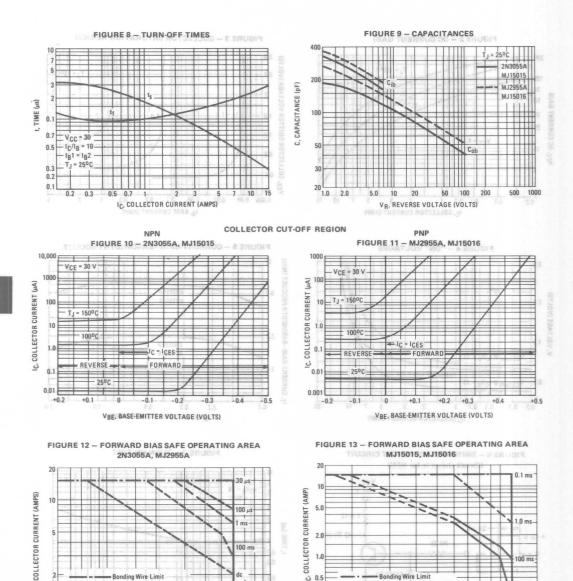












COLLECTOR CURRENT (AMP) 100 µs 100 ms Bonding Wire Limit - Bonding Wire Limit - Thermal Limit @ TC = 25°C (Single Puls - Thermal Limit @ T<sub>C</sub> = 25°C (Single Pu Second Breakdown Limit Second Breakdown Limit 0.2 20 30 60 VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS) VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe Operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figures 12 and 13 is based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 1.

100 ms-



## NPN SILICON POWER TRANSISTOR

... 2N3441 transistor is designed for use in general-purpose switching and linear amplifier applications requiring high breakdown voltages. It is characterized for use as:

- Driver for High Power Outputs
- Series and Shunt Regulators
- Audio and Servo Amplifiers
- Solenoid and Relay Drivers
- Power Switching Circuits

# 3 AMPERES NPN SILICON

POWER TRANSISTOR

140 VOLTS

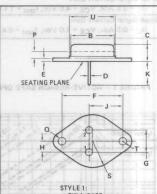


## MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	140	Vdc
Collector-Base Voltage	VCBO	160 A	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector Current — Continuous	l <sub>C</sub>	3	Adc
Base Current — Continuous	I <sub>B</sub>	2	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD I owt as ma	25 0.142	Watts W/OC
Operating and Storage Junction Temperature Range	3, 318	-65 to +200	°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	7	°C/W



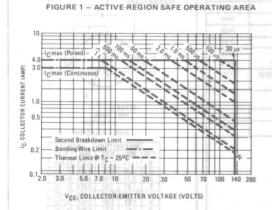
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

	MILLIMETERS		IN	CHES
DIM	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
DIS	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
E	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	-	0.360	-
P	-	1.27	-	0.050
Q	3.61	3.86	0.142	0.152
S	-	8.89	-	0.350
T	-	3.68		0.145
U	-	15.75	-	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) Unit Characteristic Symbol Min Max OFF CHARACTERISTICS Collector-Emitter Sustaining Voltage (1) Vdc 140 140 VCEO(sus) 715 AldN (IC = 100 mAdc, IB = 0) Collector Cutoff Current mA ICEO (VCE = 140 Adc, IB = 0) Collector Cutoff Current mA ICEX 5.0 (VCE = 140 Vdc, VBE(off) = 1.5 V) (VCE = 140 Vdc, VBE(off) = 1.5 V @ 150°C) 6.0 Emitter Cutoff Current 1.0 mA $(V_{BE} = 7.0 \text{ Vdc}, I_{C} = 0)$ ON CHARACTERISTICS DC Current Gain (1) hFE 100 (I<sub>C</sub> = 0.5 Adc, V<sub>CE</sub> = 4.0 V) 25 (IC = 2.7 Adc, VCE = 4.0 V) 5.0 Collector-Emitter Saturation Voltage (1) Vdc VCF(sat) (I<sub>C</sub> = 2.7 Adc, I<sub>B</sub> = 0.9 Adc) Base-Emitter On Voltage (1) (I<sub>C</sub> = 2.7 Adc, V<sub>CE</sub> = 4.0 Vdc) VBE(on) 6.7 Vdc DYNAMIC CHARACTERISTICS Small-Signal Current Gain (I<sub>C</sub> = 0.5 Adc, $V_{CE}$ = 4.0 Vdc, $f_{test}$ = 1 kHz) 15 75 hfe Small-Signal Current Gain 5.0 Ihfel (IC = 0.5 Adc, VCE = 4.0 Vdc, ftest = 0.4 MHz)



There are two limitations on the power-handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second break-

OFF CHARACTERISTICS

## HIGH-POWER INDUSTRIAL TRANSISTORS

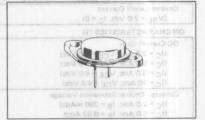
NPN silicon power transistors designed for applications in industrial and commercial equipment including high fidelity audio amplifiers, series and shunt regulators and power switches.

- Low Collector-Emitter Saturation Voltage -VCE(sat) = 1.0 Vdc (Max) @ IC = 2.0 Adc - 2N4347
- Collector-Emitter Sustaining Voltage VCEO(sus) = 120 Vdc (Min) - 2N4347 140 Vdc (Min) - 2N3442
- Excellent Second-Breakdown Capability

## 5.0 AND 10 AMPERE

## POWER TRANSISTORS NPN SILICON

120, 140 VOLTS 100, 117 WATTS



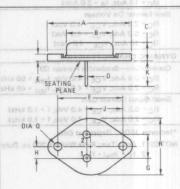
## \*MAXIMUM RATINGS

Rating	Symbol	2N4347	2N3442	2 Unit
Collector-Emitter Voltage	VCEO	120	140	Vdc
Collector-Base Voltage	OF VCB	140	160	<sup>S</sup> Vdc
Emitter-Base Voltage	VEB	7	.0	Vdc
Collector Current - Continuous Peak	IC	5.0	10 15**	Adc
Base Current — Continuous Peak	IB	3.0	7.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	100 0.57	117 0.67	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	- °C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4347	2N3442	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.75	1.5	°C/W

\*Indicates JEDEC Registered Data.



STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR

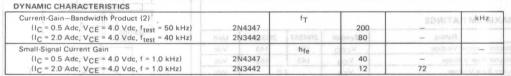
	MILLI	METERS	INC	HES		
DIM	MIN	MAX	MIN	MAX		
A	-	39.37	-	1.550		
В	-	21.08	-	0.830		
C	6.35	7.62	0.250	0.300		
D	0.99	1.09	0.039	0.043		
E	-	3.43		0.135		
OF an	29.90	30.40	1.177	1.197		
G	10.67	11.18	0.420	0.440		
H	5.33	5.59	0.210	0.220		
J	16.64	17.15	0.655	0.675		
K	11.18	12.19	0.440	0.480		
Q	3.84	4.09	0.151	0.161		
R		26.67	-	1.050		

CASE 11-01 (TO-3)

<sup>\*\*</sup>This data guranteed in addition to JEDEC registered data.

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N4347 2N3442	VCEO(sus)	120 140		Vdc
Collector Cutoff Current (V <sub>CE</sub> = 100 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 140 Vdc, I <sub>B</sub> = 0)	2N4327 2N3422	TRANSISTE	HATZUG -	AL 83 200 9-HOL 200	mAdc
Collector Cutoff Current  (VCE = 125 Vdc, VBE(off) = 1.5 Vdc)  (VCE = 140 Vdc, VBE(off) = 1.5 Vdc)  (VCE = 120 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150 <sup>C</sup> (V <sub>CE</sub> = 140 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150 <sup>C</sup>	2N4347 2N3442 C) 2N4347	esignerX321 app including high fill ad power switches	unemqiupi	sdicon nower tr and co.5 nercial 5.0 cries of shunt 30	mAdo
Emitter Cutoff Current (VBE = 7.0 Vdc, IC = 0)	2N4347, 2N3442	ENO A O.S.	fax) @ tc =	1) 45V (5.0 = (ma) 3	mAdo
ON CHARACTERISTICS (1)			ing Voltage	tor Emitter Sustain	pallo?
DC Current Gain (IC = 2.0 Adc. VCE = 4.0 Vdc)	2N4347			EO(sus) = 120 Vdc	3V -

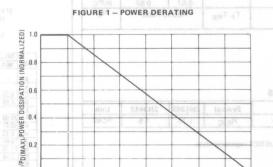
ON CHARACTERISTICS (1)					oallo`i e
DC Current Gain		hpe 7466	(Min) - 25	EO(sus) = 120 Vdc	yV -
(I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N4347		15		
(IC = 5.0 Adc, VCE = 4.0 Vdc)	2N4347		10	_	
(IC = 3.0 Adc, VCE = 4.0 Vdc)	2N3442		den 20 m/o	hasan B (70 oced line	BOX F 18
(IC = 10 Adc, VCE = 4.0 Vdc)	2N3442		7.5		
Collector-Emitter Saturation Voltage		VCE(sat)			Vdc
(IC = 2.0 Adc, IB = 200 mAdc)	2N4347		-	1.0	
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.63 Adc)	2N4347		-	2.0	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc)	2N3442		-	5.0	
Base-Emitter On Voltage		VBE(on)			Vdc
(I <sub>C</sub> = 2.0 Adc; V <sub>CE</sub> = 4.0 Vdc)	2N4347			2.0	
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N4347		-	3.0	
(IC = 10 Adc, VCF = 4.0 Vdc)	2N3442		_	5.7	



\*Indicates JEDEC Registered Data

NOTES: 1. Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2.0%.

2. fT = |hfe| · ftest



25

50 75

0

5

100

TC, CASE TEMPERATURE (°C)

125

150 175

APPLICATIONS

# AJCHOTON

## ACTIVE REGION SAFE OPERATING AREA INFORMATION

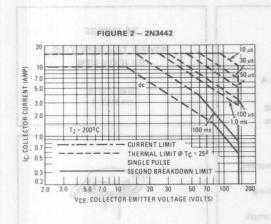


FIGURE 3 - 2N4347

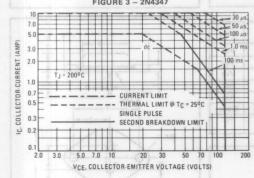
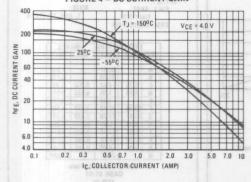


FIGURE 4 - DC CURRENT GAIN



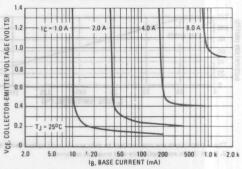
 F. at Switching: Total Switching Time = 1.2 ps (Typ) @ 5.0 A 4 Holt Gain: Han = 40 to 120 0 5 0 Amer (2019/67/48) . Courrentsed DC Sate Ares: 1,5 Amps (thin) @ Vog = 40 Vuc Low VCE(sat): 1.0 Volt (Typ), 1.5 Volts (Max) ⊕ 6.0 Arros # Excellent Beta Linearity

> of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

There are two limitations on the power-handling ability

The data of Figures 2 and 3 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$ is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 5 - COLLECTOR-SATURATION REGION







ACTIVE REGION SAFE OPERATING AREA INFORMATION

# HIGH-SPEED SILICON ANNULAR NPN POWER TRANSISTORS

... for switching and amplifier applications

### **FEATURES**

- Fast Switching: Total Switching Time = 1.2  $\mu$ s (Typ) @ 5.0 A
- High Gain: HFE = 40 to 120 @ 5.0 Amps (2N3447-48)
- Guaranteed DC Safe Area: 1,5 Amps (Min) @ VCF = 40 Vdc
- Low VCE(sat): 1.0 Volt (Typ), 1.5 Volts (Max) @ 5.0 Amps
- Excellent Beta Linearity

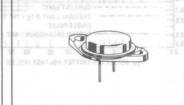
## **APPLICATIONS**

- Specified safe area of this series allows reliable design for inverters, converters, hammer, and servo drivers.
- Fast response makes it ideal for series regulators; high switching speeds enhance its use in switching regulators.
- Wide bandwidth and flat beta hold-up result in exceptional amplifier characteristics.

## 7.5 AMPERE

## POWER TRANSISTORS SILICON NPN

60-80 VOLTS 115 WATTS



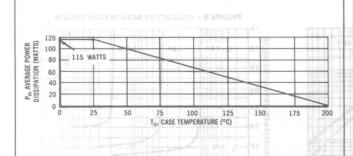
SEATING

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

## MAXIMUM RATING: yel biscogmi and resimile sty reads gast applies of

Rating	Symbol	2N3445 2N3447	2N3446 2N3448	Unit
Collector-Emitter Voltage	VCEO	60 80		Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	6.0 10		Vdc
Collector Current-Continuous	1 <sub>C</sub>	7	Adc	
Base Current - Continuous	I <sub>B</sub>	4	Adc	
Total Device Dissipation	PD	Figure 1, 2	Figure 1, 3	Watts
Operating Junction Temperature Range	TJ	-65 to	°C	





These transistors are also subject to safe area curves as indicated by Figures 2, 3. Both limits are applicable and must be observed.

NOTE: 1. DIM "Q" IS DIA.

CASE 11-01 (TO-3)

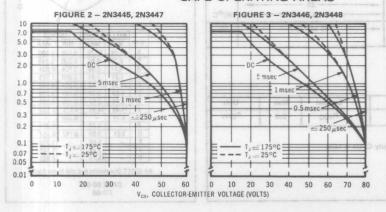




## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
Emitter-Base Cutoff Current (V <sub>EB</sub> = 6 Vdc) (V <sub>EB</sub> = 10 Vdc)	2N3445, 2N3447 2N3446, 2N3448	IEBO	-	_	0.25 0.25	mAdc
Collector-Emitter Cutoff Current (VCE = 60 Vdc, VBE = -1 Vdc) (VCE = 60 Vdc, VBE = -1 Vdc, TC = 150°C) (VCE = 80 Vdc, VBE = -1 Vdc)	2N3446, 2N3448	ICEX	=	-	0.1 1.0 0.1	mAdc
(V <sub>CE</sub> = 80 Vdc, V <sub>BE</sub> = -1 Vdc, T <sub>C</sub> = 150°C)	2N3446, 2N3448		-	-	1.0	0 -1-
Collector-Emitter Cutoff Current (VCE = 40 Vdc, I <sub>B</sub> = 0) (VCE = 60 Vdc, I <sub>B</sub> = 0)	2N3445, 2N3447 2N3446, 2N3448	TON HOTH	N-POINER	V MEDIU	1.0 HM	mAdc BLIGMOS
Collector-Base Breakdown Voltage (I <sub>C</sub> = 1 mAdc, I <sub>E</sub> = 0)	2N3445, 2N3447 2N3446, 2N3448	BVCBO	80 100			Vdc
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N3445, 2N3447 2N3446, 2N3448	VCEO(sus)		speed swite oper <del>a</del> tional ellec <del>ri</del> on si	ed for high ligh-veltage inverters, d	lons for
DC Current Gain (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 5 Adc, V <sub>CE</sub> = 5 Vdc)	2N3445, 2N3446 2N3447, 2N3448 2N3445, 2N3446 2N3447, 2N3448	hFE obAm 00	20 40 20	45 85 40	- - 60 120	C I feete
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 0.3 Adc) (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc)	2N3445, 2N3446 2N3447, 2N3348	VCE(sat)	rent – 0 VdZ – N	0.6	1.5 as	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 0.3 Adc) (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc)	2N3445, 2N3446 2N3447, 2N3338	VBE(sat)	_ skAc _	1.0	1.5	Vdc
Base-Emitter Voltage (IC = 3 Adc, VCE = 5 Vdc) (IC = 5 Adc, VCE = 5 Vdc)	2N3445, 2N3446 2N3447, 2N3448	VBE	=	1.0	1.5 1.4	Vdc
Small Signal Current Gain (VCE = 10 Vdc, I <sub>C</sub> = 0.5 Adc, f = 1 KHz) (VCE = 10 Vdc, I <sub>C</sub> = 0.5 Adc, f = 10 MHz)	2N3445, 2N3446 2N3447, 2N3448	h <sub>fe</sub>	20	- 203	100 200	AR MUM
Common Base Output Capacitance (VCB = 10 Vdc, f = 0.1 MHz)	All Types	Cob	085 880	1.6	400	1971 pf 3-10
Switching Times $(V_{CC} = 25 \text{ Vdc}, R_L = 5 \text{ ohms}, I_C = 5 \text{ A, } I_{B1} = 0 \text{ Delay Time plus Rise Time }$ Storage Time Fall Time	I <sub>B2</sub> = 0.5 A)	t <sub>d</sub> + t <sub>r</sub> t <sub>s</sub>	= 0	0.15 0.9 0.15	0.35 2.0 0.35	μς sricV e. sc -toemen to

## SAFE OPERATING AREAS



The Safe Operating Area Curves indicate IC - VCE limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collectoremitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T<sub>J</sub> the power-temperature derating curve must be observed for both steady state and pulse power conditions.



ELECTRICAL CHARACTERISTICS

## COMPLEMENTARY MEDIUM-POWER HIGH VOLTAGE POWER TRANSISTORS

. . . designed for high-speed switching and linear amplifier applications for high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

- Collector-Emitter Sustaining Voltage VCEO(sus) = 175 to 300 Vdc @ IC = 200 mAdc
- Second Breakdown Collector Current  $I_{s/b}$  = 350 mAdc @ VCE = 100 Vdc - NPN = 150 mAdc @ VCF = 100 Vdc - PNP
- Usable DC Current Gain to 2.0 Adc

## 1.0 AND 2.0 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

> 250-500 VOLTS 35 WATTS



## \*MAXIMUM RATINGS

Rating —	Symbol	2N3583 2N6420	2N3584 2N6421	2N3585 2N6422	2N4240 2N6423	Unit
Collector-Emitter Voltage	VCEO	175	250	300	300	Vdc
Collector-Base Voltage	VCB	250	375	500	500	Vdc
Emitter-Base Voltage	VEB	-	6.	0	-	Vdc
Collector Current - Continuous -Peak (1)	IC B.	1.0 5.0	-	— 2.0 — — 5.0 —	-	Adc
Base Current	rent IB 1.0				-	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25°C,  Derate above 25°C	PD ZATRA DATTAR					
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200				

## THERMAL CHARACTERISTICS

Characteristic Diova	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	5.0	°C/W

\*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

SEATING PLANE STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR MILLIMETERS INCHES

DIM	MIN	MAX	MIN	MAX			
В	11.94	12.70	0.470	0.500			
C	6.35	8.64	0.250	0.340			
D	0.71	0.86	0.028	0.034			
E	1.27	1.91	0.050	0.075			
F	24.33	24.43	0.958	0.962			
G	4.83	5.33	0.190	0.210			
H	2.41	2.67	0.095	0.105			
J	14.48	14.99	0.570	0.590			
K	9.14	-	0.360	-			
P		1.27		0.050			
0	3.61	3.86	0.142	0.152			
S	-	8.89		0.350			
T	-	3.68		0.145			
U		15.75	4	0.620			

CASE 80-02 TO-66

20 30 40 60 60 70 90

MPAL PAIR									
Min Max Min Max Unor		999	MENA	1		piteisoto			
					-				
SHM					MAD -	Vulc, fun			
- 10 - 01				1					
LECTRICAL CHARACTERISTICS (TC = 2	25°C unles	s otherwise	noted.)						
					NP	N	P	NP	:uqsu
Characteristic Characteristic	doO	NPN	PNP	Symbol	Min	Max	Min	Max	Uni
OFF CHARACTERISTICS (1)	nin.						nt Gain	nal Cumar	pi8-lise
Collector-Emitter Sustaining Voltage		2N3583	2N6420	VCEO(sus)	175	PILODVI	175	pesan po	Vdd
(I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0) NPN		2N3584	2N6421		250	83118	250	AHILDIN	HOTEV
		2N3585	2N6422		300	-	300	-	niT sa
(I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0) PNP	7	2N4240	2N6423	1 20	300	Add: True	300	200 Vds	2272
Collector Cutoff Current		2146422	CNISSES	ICEO			(1	bium 001	mAd
(VCE = 150 Vdc, IB = 0)		2N3583	2N6420	,emi	0 585 -	A 10 A	1c = 0.7	10	OD VA
		2N3584	2N6421		-	5.0	-	5.0	181
		2N3585	2N6422		-	5.0	-	5.0	50810
	8	2N4240	2N6423		-	5.0	Dir = ni	5.0	2000
Collector Cutoff Current		2NIG622	2N3586	ICEX			(lelpiAim	101 = CE	mAd
(VCE = 225 Vdc, VBE(off) = 1.5 Vdc)	M = 91	2N3583	2N6420		-	1.0	1c=0.7	1.0	2019
(V <sub>CE</sub> = 340 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)	- 3	2N3584	2N6421		-	1.0	HabAn	1.0	18
(V <sub>CE</sub> = 450 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)		2N3585	2N6422			1.0		1.0	n Tih
14 005 M M M M M M M M M M M M M M M M M M	OUO	2N4240	2N6423		-	2.0 3.0	0.12 31	2.0	35V9
(VCE = 225 Vdc, VBE(off) = 1.5 Vdc, TC = 15		2N3583	2N6420			3.0	(nhAm	3.0	
(VCE = 300 Vdc, VBE(off) = 1.5 Vdc, TC = 15	10-C)	2N3584 2N3585	2N6421 2N6422			3.0	to = 0.7	3.0	181 (VCC
0.6 - 0.6 -		2N3585 2N4240	2N6422 2N6423		_	5.0	Lab An	5.0	181
5 :		2144240	2110120	la		0.0		0.0	mAd
Emitter Cutoff Current		2N3583	2N6420	IEBO		5.0		5.0	mAd
(V <sub>BE</sub> = 6.0 Vdc, I <sub>C</sub> = 0)		2N3584	2N6420 2N6421			0.5		0.5	
renan	- Blut	2N3585	2N6422		_	0.5	sersatio2	0.5	s bnab
350 - 081 - 086		2N4240	2N6423		_	0.5	_	0.5	E BOM
ON CHARACTERISTICS (1)	-					sta (	I bareteige	R DROB	eteall
DC Current Gain		All	All	hFE				Jest 1 4 lo	ो ध
(I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 10 Vdc)					40	-	40	-	
*(IC = 0.5 Adc, VCE = 10 Vdc)		2N3583	2N6420		40	200	40	200	
*(IC = 0.75 Adc, VCE = 2.0 Vdc)		2N4240	2N6423		10	100	10	100	
(I <sub>C</sub> = 0.75 Adc, V <sub>CE</sub> = 10 Vdc)	100	2N4240	2N6423	- 7 - 3	30	150	30	150	
*(IC = 1.0 Adc, VCE = 2.0 Vdc)		2N3584	2N6421		8.0	80	8.0	80	
		2N3585	2N6422		8.0	80	8.0	80	
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc)	ORIO TES	2N3583*	2N6420	- 1 BRUS	10	-	10	-	
		2N3584	2N6421		25	100	25	100	
	200	2N3585	2N6422		25	100	25	100	
	Q+200-		517 0	VCE(sat)	No. 17			Marin 18	Vd
(I <sub>C</sub> = 0.75 Adc, I <sub>B</sub> = 75 mAdc)		2N4240	2N6423		VIH	1.0	-	1.0	
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 125 mAdc)	388	2N3583	2N6420		- 0	5.0	-	5.0	
	1	2N3584	2N6421		- sv	0.75	-	0.75	1 11
34038 C		2N3585	2N6422	1 V 0.8	-	0.75	-	0.75	
Base-Emitter Saturation Voltage	KI	1	88	VBE(sat)					Vd
(I <sub>C</sub> = 0.75 Adc, I <sub>B</sub> = 75 mAdc)	( }	2N4240	2N6423	-0.	-	1.8	-	1.8	
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)	101	2N3584	2N6421		-	1.4	-	1.4	
		2N3585	2N6422		-	1.4	-	1.4	
Base-Emitter On Voltage		All	All	V <sub>BE(on)</sub>	24 (1.4)			SATIO	Vdd
				DE(OII)	DYD Y TUE	1.4		1.4	1

(I<sub>C</sub> = 1.0 Adc, V<sub>CE</sub> = 10 Vdc)
\*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300  $\mu s,$  Duty Cycle  $\leqslant$  2%.

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

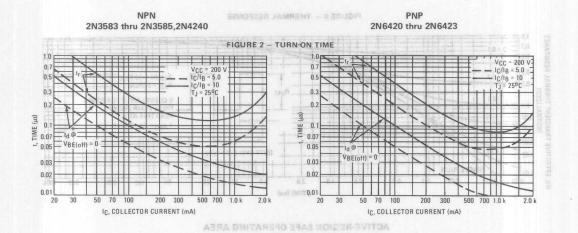
				1	IPN	P	NP	
Characteristic	NPN	PNP	Symbol	Min	Max	Min	Max	Unit
DYNAMIC CHARACTERISTICS								
*Current Gain — Bandwidth Product <sup>(1)</sup> ( $I_C = 200 \text{ mAdc}$ , $V_{CE} = 10 \text{ Vdc}$ , $f_{test} = 5.0 \text{ MHz}$ )	2N3583 2N3584 2N3585	2N6420 2N6421	fT	10	-	10	-	MHz
	2N4240	2N6422 2N6423	25°C unia	15	ERISTIC	TOARAI	ICAL CI	LECT
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz) and loc	NAP Symb	NEN	C <sub>ob</sub>	_	120	Chara	120	pF
Small-Signal Current Gain			h <sub>fe</sub>			STICS (I	MACTER	FE CH.
(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 30 Vdc, f = 1.0 kHz)	2N3583	2N6420		25	350	25	350	inello
SWITCHING CHARACTERISTICS 085	2N6421	2N3584			MA	N (0 = g)	abAm 00:	* 9H
Rise Time $(V_{CC} = 200 \text{ Vdc}, I_C = 1.0 \text{ Adc}, R_L = 200 \text{ Ohms},$	2N3584	2N6421	t <sub>r</sub>	_	3.0	8 = <u>0</u> ) Ph	3.0	μs
I <sub>B1</sub> = 100 mAdc) (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 0.75 Adc, R <sub>L</sub> = 267 Ohms, I <sub>B1</sub> = 75 mAdc)	2N3585 2N4240	2N6422 2N6423		-	0.5	(0 = g1	0.5	erselto0 30 MI
Storage Time (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 1.0 Adc,	2N3584	2N6421	t <sub>s</sub>		4.0		4.0	μs
I <sub>B1</sub> = I <sub>B2</sub> = 100 mAdc) (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 0.75 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 75 mAdc)	2N3585 2N4240	2N6422 2N6423		-	6.0	ment Molagy Molagy	6.0	WGE WGE
Fall Time (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 1.0 Adc, 5 I <sub>B1</sub> = I <sub>B2</sub> = 100 mAdc) (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 0.75 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 75 mAdc)	2N3584 2N3585 2N4240	2N6421 2N6422 2N6423		T <sub>C</sub> - 18	3.0		3.0 S 50V 002 - 3.0	μς (VQE
- Am	nau <sup>1</sup>					108	do Hote.	estim?
0.8 - 0.8 -		143089 V				(0 - 0)	'00A A'S .	38×1
Second Breakdown Collector Current (VCE = 100 Vdc)	2N6422	All	I <sub>s/b</sub>	350	_	150	_	mAdc

RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D<sub>1</sub> MUST BE FAST RECOVERY TYPE, eg: MBD5300 USED ABOVE IB  $\approx$  100 mA MSD6100 USED BELOW IB  $\approx$  100 mA

FOR  $t_d$  and  $t_r$ , D1 IS DISCONNECTED AND  $V_2 = \emptyset$ , FOR PNP TEST CIRCUIT, REVERSE DIODE AND VOLTAGE POLARITIES.

FIGURE 7 - 2N3583 thtu 2N3585, 2N4240



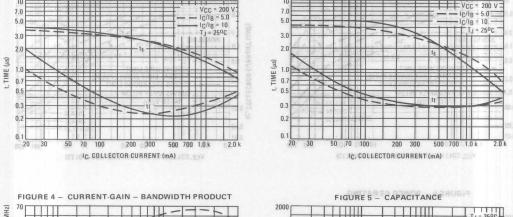
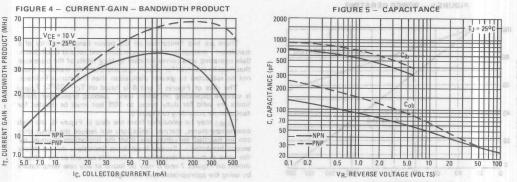
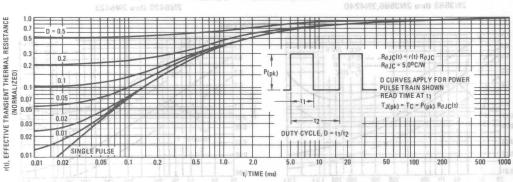


FIGURE 3 - TURN-OFF TIME



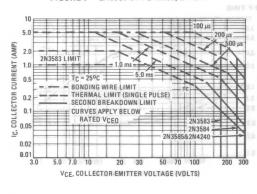




## **ACTIVE-REGION SAFE OPERATING AREA**

FIGURE 7 - 2N3583 thru 2N3585, 2N4240

FIGURE 8 - 2N6420 thru 2N6423



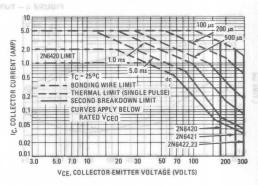
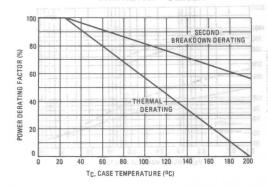


FIGURE 9 - POWER DERATING

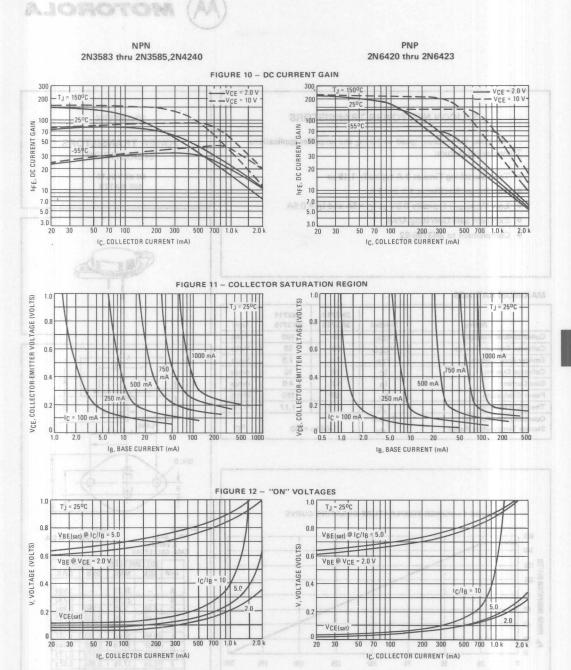


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 7 and 8 is based on  $T_C = 25^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 9.

TJ(pk) may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 7 and 8 may be found at any case temperature by using the appropriate curve on Figure 9.

## 2N3583 thru 2N3585 • 2N4240 - NPN 2N6420 thru 2N6423 - PNP



2N3713 thru 2N3716 nen

NOTE: DC CURRENT LIMIT FOR 2N3583, 2N6420 is 1.0 Amp.

2N3583 thru 2N3585,2M6240

2N358 thru 2N3585 • 2N4240 - NPN

# SILICON NPN POWER TRANSISTORS

... designed for medium-speed switching and amplifier applications. These devices feature:

- Total Switching Time at 3 A typically 1.15 μs
- Gain Ranges Specified at 1 A and 3 A
- Low VCE(sat): typically 0.5V at IC = 5A and IB = 0.5A
- Excellent Safe Operating Areas
- Complement to 2N3789-92

#### 10 AMPERE

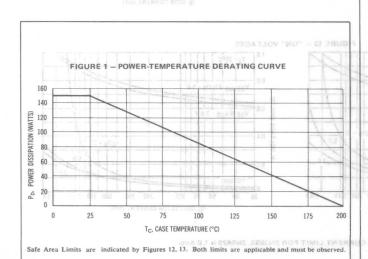
POWER TRANSISTORS SILICON NPN

> 60-80 VOLTS 150 WATTS



# MAXIMUM RATINGS

Rating	Symbol	2N3713 2N3715	2N3714 2N3716	Unit
Collector-Base Voltage	VCB	80	100	Volts
Collector-Emitter Voltage	VCEO	60	80	Volts
Emitter-Base Voltage	VEB	7.0	7.0	Volts
Collector Current	Ic	10	10	Amps
Base Current	IB	4.0	4.0	Amps
Power Dissipation	PD	150	150	Watts
Thermal Resistance	θJC	1.17	1.17	°C/W
Operating Junction and Storage Temperature Range	T <sub>J</sub> and T <sub>stg</sub>	-65 to +200		°C



NOTE: PIN 1. BASE 2. EMITTER 1. DIM "Q" IS DIA. CASE: COLLECTOR

	MILLI	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A		39.37	111	1.550	
В	-	21.08	1+1	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E		3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
H	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	-	26.67	-	1.050	

Collector connected to case. **CASE 11-01** (TO-3)

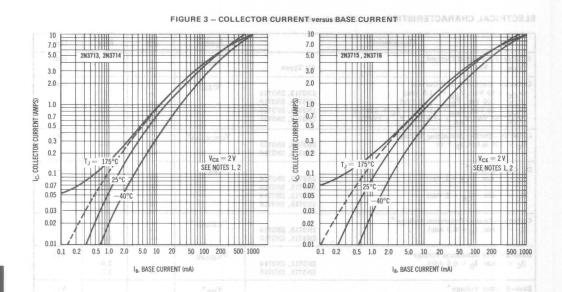
100

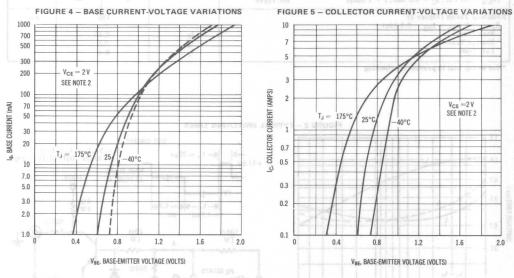
# ELECTRICAL CHARACTERISTICS (TC = 25° C unless otherwise noted)

Characteristic	E 0.7 E	Symbol	Min	Max	Unit
Enitter-Base Cutoff Current (V <sub>EB</sub> = 7 Vdc)	All Types	IEBO		5	mAde
	2N3713, 2N3715 2N3714, 2N3716 2N3713, 2N3715 2N3714, 2N3716			1 1 10 10	mAde
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N3713, 2N3715 2N3714, 2N3716	V <sub>CEO(sus)</sub> *	60 80	<u></u>	Vdc
DC Current Gain * (I <sub>C</sub> = 1 Adc. V <sub>CE</sub> = 2 Vdc) (I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2 Vdc)	1 Adc. V <sub>CE</sub> = 2 Vdc) 2N3713, 2N3714 2N3715, 2N3716		25 50 15 30	90 150 —	1.0 10.6 30.0
Collector-Emitter Saturation Voltage * (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc) /	2N3713, 2N3714 2N3715, 2N3716	V <sub>CE(sat)</sub> *		1.0 0.8	Vdc
Base-Emitter Saturation Voltage * 0.4 0.6 0.6 (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc)	2N3713, 2N3714 2N3715, 2N3716	VBE(sat) *	9,6 10 20 1 <sub>0</sub> , 88, <u>57</u> CURPE	2.0 1.5	Vdc
Base-Emitter Voltage* (I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2 Vdc)	All Types	V <sub>BE</sub> *	_	1.5	Vdc
Small Signal Current Gain (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> = 0.5 Adc, f = 1 MHz)	All Types	h <sub>fe</sub>	4		-
Switching Times (Figure 2) (I $_{\rm C}=5{\rm A_1}{\rm I}_{\rm B1}={\rm I}_{\rm B2}=0.5{\rm Adc})$ Rise Time Storage Time Fall Time	100 100 100 100 100 100 100 100 100 100	t <sub>r</sub> t <sub>s</sub> t <sub>f</sub>	0.4 0.3 0.4	15	μs 9001 900 900

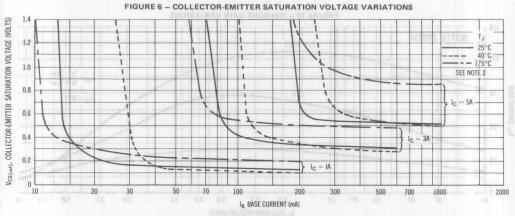
\*Use sweep test to prevent overheating

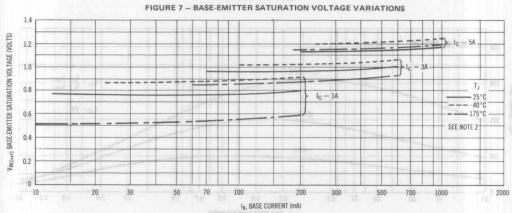
FIGURE 2 - TYPICAL SWITCHING TIMES 1.5 TEST CIRCUIT  $I_{\rm C}=5\,{\rm A},\,I_{\rm B1}=I_{\rm B2}=0.5\,{\rm A}$  f = 150 cps DUTY CYCLE  $\approx 2\,\%$ 1.0 +11.5V WAVE SHAPE 0.7 AT POINT A SWITCHING TIMES (yes.) -9V 0.5 ~ 1.7 ms ms 900Ω 0.3 100Ω 1W 20Ω 1W A 0.2 - I<sub>B2</sub> 900Ω Hg RELAYS 40 100Ω ≸ ... втои 0.1 0.2 0.3 0.5 0.7 1.0 2.0 3.0 -9V ₹100Ω Ic, COLLECTOR CURRENT (AMPS) -4V

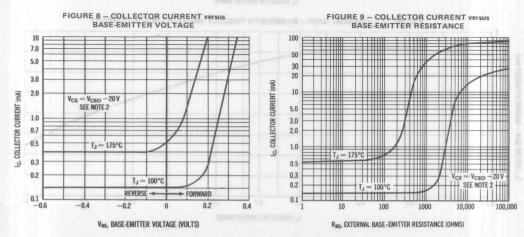


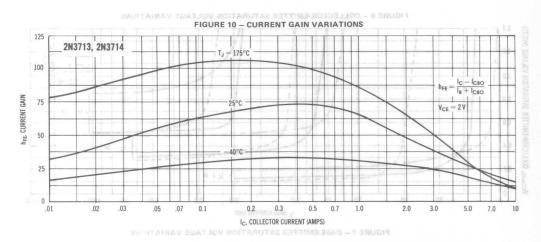


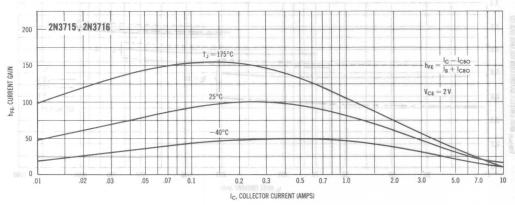
NOTE 1. Dotted line indicates metered base current plus the IcBo of the transistor at 175°C , NOTE 2. Pulse test: pulse width  $\approx 200$  µsec, duty cycle  $\approx 1.5\%$ 

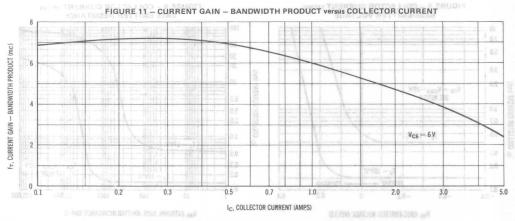


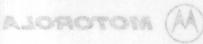






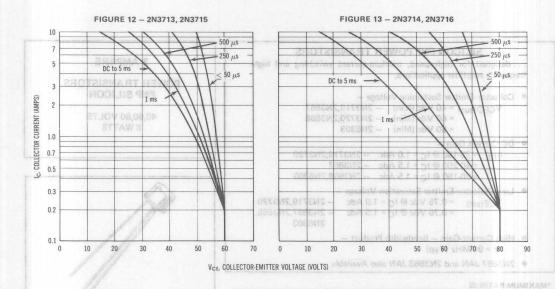






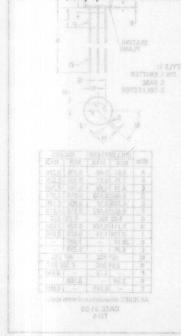
2N3719, 2N3720 2N3867, 2N3868 2N6303

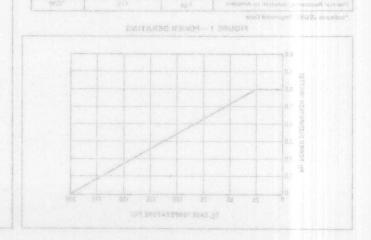
#### SAFE OPERATING AREAS



The Safe Operating Area Curves indicate  $I_{\rm C} - V_{\rm CE}$  limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collectoremitter short. (Duty cycle of the excursions make no signifi-

cant change in these safe areas.) To insure operation below the maximum T<sub>J</sub>, the power-temperature derating curve must be observed for both steady state and pulse power conditions.







#### SILICON PNP POWER TRANSISTORS

... designed for high-speed, medium-current switching and highfrequency amplifier applications.

Collector-Emitter Sustaining Voltage —

VCEO(sus) = 40 Vdc (Min) - 2N3719,2N3867 = 60 Vdc (Min) - 2N3720,2N3868

= 80 Vdc (Min) - 2N6303

DC Current Gain —

hFE = 25-180 @ IC = 1.0 Adc - 2N3719,2N3720

= 40-200 @ I<sub>C</sub> = 1.5 Adc — 2N3867 = 30-150 @ I<sub>C</sub> = 1.5 Adc — 2N3868,2N6303

Low Collector-Emitter Saturation Voltage —

V<sub>CE</sub>(sat) = 0.75 Vdc @ I<sub>C</sub> = 1.0 Adc = 2N3719,2N3720 = 0.75 Vdc @ I<sub>C</sub> = 1.5 Adc = 2N3867,2N3868,

2N6303

High Current-Gain — Bandwidth Product —

fT = 90 MHz (Typ)

• 2N3867 JAN and 2N3868 JAN also Available

#### \*MAXIMUM RATINGS

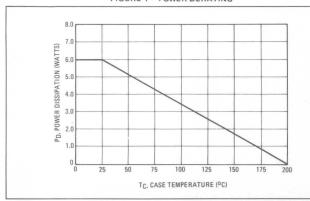
Rating	Symbol	2N3719 2N3867	2N3720 2N3868	2N6303	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	-	Vdc	
Collector Current - Continuous Peak	1C	-	Adc		
Base Current	I <sub>B</sub>	-	Adc		
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	-		Watts mW/°C	
Total Device Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	4	Watt mW/°C		
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +200		°c

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	θЈС	29	°C/W	
Thermal Resistance, Junction to Ambient	$\theta$ JA	175	°C/W	

<sup>\*</sup>Indicates JEDEC Registered Data

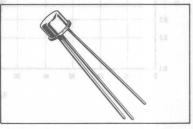
#### FIGURE 1 - POWER DERATING

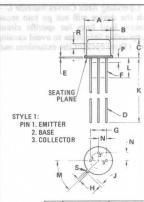


# 3 AMPERE

#### **POWER TRANSISTORS** PNP SILICON

40,60,80 VOLTS 6 WATTS





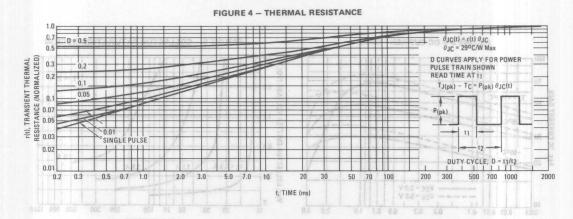
	MILLIN	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
Α	8.51	9.40	0.335	0.370	
В	7.75	8.51	0.305	0.335	
C	6.10	6.60	0.240	0.260	
D	0.406	0.533	0.016	0.021	
E	0.229	3.18	0.009	0.125	
F	0.406	0.483	0.016	0.019	
G	5.08	BSC	0.200 BSC		
Н	0.711	0.864	0.028	0.034	
J	0.734	1.14	0.029	0.045	
K	38.10	-	1.500	-	
L	6.35	-	0.250	-	
M	450	BSC	450	BSC	
N	2.5	4 BSC	0.10	O BSC	
P	-	1.27	-	0.050	
R	2.54	-	0.100	-	
S	-	0.179	-	0.007	

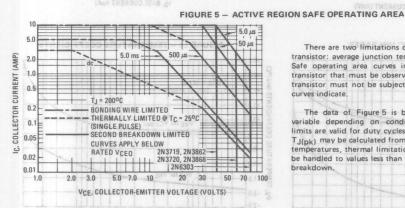
All JEDEC dimensions and notes apply. CASE 31-03 TO-5

ELECTRICAL CHARACTERISTICS /	- 2500	vice was add		and the second second	
ELECTRICAL CHARACTERISTICS (7 Characteristic	C = 25°C unless other	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	1202/0/207	ANTONE	1000	dc, lg = 0)	- 100 - 41
		282.286		10 - 9 ,00	Vdc
Collector-Emitter Sustaining Voltage (1) (IC = 20 mAdc, IB = 0)	2N3867	VCEO(sus)	40	record to	Vac
SALL OF SALL	2N3868	203719	60	t = mol=aV ob	
	2N6303	2013728	80 00	i = High EgV abi	100 = 30V1
Collector-Base Breakdown Voltage		BVCBO	Vec, To=150°C	dc. Vas (arr) = Z.	Vdc
(I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	2N3867	2/13/20	40 abv	dc, Vec+ods) = 2.0	1ACE + 80 A
abeli ale	2N3868	-	60	if Consume	u3 prosite
01 -	2N6303	2N3719	80	(0 = g) ,ob	(VGB = 40 V)
Emitter-Base Breakdown Voltage		BVEBO		(ic, lg = 0)	Vdc
(I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)	0831		4.0	Trans3	Hairter Cutor
Collector Cutoff Current		ICEX		/dc, ig = 0).	μAdc
(V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 2.0 Vdc)			- (	2011.0	MICHARA
Collector Cutoff Current	T and 1	СВО		ni	μAdc
(V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0, T <sub>C</sub> = 150°C)			- (6)	/ a. 150 / on/	1003 = 500
ON CHARACTERISTICS (1)				S, Vot = 1.5 Vac)	640,7 4011
DC Current Gain		hFE	10.01	104 FU - 304 F	2.4.0.18 _ Q10
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	2N3867	to Dougle	50	ter Saturation Ve	m3-retoalle
20.0	N3868, 2N6303	(3000t+	00	c, lg = <u>1</u> 00 mAd.	0.1 = 50
(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	2N3867	1300013	40	200	(1g = 3,0 a c
20 Z	N3868, 2N6303		30	150	Trustim 3-eas
(I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N3867	(3)90014	23	. lg = 100 mAde	OA O.F = all
21	N3868, 2N6303	(0%001)	20	bAm 002 = g1,c	8A 0.E = 3B
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	2N3867		20	HARACTERIS	PRINTE
CHAMILTON TO THE CONTRACT OF T	N3868, 2N6303		(c) (2)	Bandwidth Prose	great-Gain
Collector-Emitter Saturation Voltage		VCE (sat)	c, f <sub>1652</sub> = 30 MHz	V 01 = 30V ,abi	Vdc
(I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc)			_	0.5	cace() sugge
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 150 mAdc)			1/4Hz)	0.75	(Vice * 10 )
(I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 250 mAdc)				1.3	
Base-Emitter Saturation Voltage		V <sub>BE</sub> (sat)	(s)H86	1ds, 1c - 0, 1 = 0	Vdc
(I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc) (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 150 mAdc)			0.9	1.0	DIMERSTIN
(IC = 2.5 Adc, IB = 250 mAdc)			-	2.0	miT-eO-ms
DYNAMIC CHARACTERISTICS	007	(abA 1.0 = 1	ic = 1.0 Ade. in	dt. Vertiner = 0.	V \$1 = -y (V)
			T	T INTO SO	Last Sauss
Current-Gain – Bandwidth Product (2) ( $I_C = 100 \text{ mAdc}$ , $V_{CE} = 5.0 \text{ Vdc}$ , $f_{test} = 20$	MU-1	fT	101 = 560 181	50, 10 1 1.0 Add	MHz
	IVITIZ)		200 18	- 3 10	Committee of the last
Output Capacitance	No.	Cob	678	120	Top Top I
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	this tales.	Li ist Work a	Bas, Cary Cycle	120	
Input Capacitance (VEB = 3.0 Vdc, I <sub>C</sub> = 0, f = 0.1 MHz)		C <sub>ib</sub>	G TIMES YEST	1000	pF
SWITCHING CHARACTERISTICS	the latest and the la		nov		
Delay Time (VCC = 30 Vdc, VBE(off) = 0	START IN	t <sub>d</sub>	-	35	ns
Rise Time I <sub>C</sub> = 1.5 Adc, I <sub>B1</sub> = 150 mAc		tr	NS -	65	ns
71			Lane -	325	ns
1 4 CC - 30 Age, 16 - 1.3 Age,		t <sub>s</sub>	M		
Fall Time   IB1 = IB2 = 150 mAdc)		tf	1 7	75	ns

<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%. (2)  $f_T = |h_{fe}| = f_{test}$ .

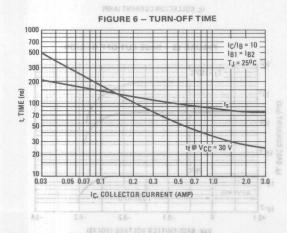
Characterist			nless otherwi	Symbol	Min	Max	Unit
OFF CHARACTERISTICS			(DEIGN BEILVI	arbe spillio of st.	OTT BOITEME	TOATANOUA	210 (034)
Collector-Emitter Sustaining Voltage (1)		lodin	6	VCEO(sus)	2015 W1361W1	P	Vdc
(I <sub>C</sub> = 20 mAdc, I <sub>B</sub> = 0)		2N37	19	020(303)	40	ACTE MISTRES	DEE CHAR
) Vale		2N37	20		60	ter Sustaining V	mi in reportion
Collector Cutoff Current		(min)		ICEX		(dc, 1g = 0)	11g = 20 ma
(V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> (off) = 2.0 Vdc) (V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> (off) = 2.0 Vdc)		2N37 2N37		2N3998 2N6393	_	10 10	μAdc
(V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> (off) = 2.0 Vdc, T <sub>C</sub> (V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> (off) = 2.0 Vdc, T <sub>C</sub>	= 150°C	2N37 2N37		2843867	— age	Bree . 0.1 Vol.	
Collector Cutoff Current				СВО			μAdc
(V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)		2N37		COCOLA		10	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)		2N37	/20		- 4	allow AU banes	esa : - rottien
Emitter Cutoff Current (VBE = 4.0 Vdc, IC = 0)		X30		IEBO	_	1.0	mAdc
ON CHARACTERISTICS (1)	1	73650			(0)5 V (1) 5 = (	tto) 38 V 480 V DE	MAN HOLE
DC Current Gain		(183	1	hee	T	mango n	STUD TOTOSTIO
(IC = 500 mAdc, VCE = 1.5 Vdc)					20	d V <sub>CB</sub> . <u>18</u> = 0.	(Vcg · Rat
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.5 Vdc)					25	180	
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.5 Vdc, T <sub>C</sub> = -4	10°C)	220		and the second	15	nie nie	O Cum e C.G
Collector-Emitter Saturation Voltage		0		VCE(sat)	(ab)	1000	Vdc
$(I_C = 1.0 \text{ Adc}, I_B = 100 \text{ mAdc}, T_C = -60 \text{ mAdc}, T_C $				88, 21/6903	21434	0.75	
	40 0 10	+100 C/		2M3867	10140	6, Vo. 1.5	Vdc
Base-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 100 mAdc, TC =	40°C to	+100°C)		VBE(sat)	ENS -	by 6.51.5 <sub>20</sub> V a	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 300 mAdc, T <sub>C</sub> = -				88. 2N830G		2.3	
DYNAMIC CHARACTERISTICS				21/13867		a, V <sub>CE</sub> = 5,0 Vdc	(IC + 3.0 Ac
Current-Gain — Bandwidth Product (2)				f <sub>T</sub>	293		MHz
(IC = 500 mAdc, VCE = 10 Vdc, ftest	= 30 MH	z) (	oV I		60 sparts	rer Saturation V	im3 modic
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)				C <sub>ob</sub>	_ (s)	Am 0 <sub>120</sub> al	PF SAd
Input Capacitance (VEB = 0.5 Vdc, IC = 0, f = 0.1 MHz)		E (set)	ieV Ve	C <sub>ib</sub>	_	1000	pF
WITCHING CHARACTERISTICS					I Int	ic. (g = 150 mAce	man sent
Turn-On Time	-		-	T +	I 9	p. 1g = 250 cmAd	bAdS ns
(V <sub>CC</sub> = 12 Vdc, V <sub>BE</sub> (off) = 0, I <sub>C</sub> = 1.0	Adc, I <sub>E</sub>	31 = 0.1 /	Adc)	ton	rics-	93 100 AH	YNAMIC
Turn-Off Time (V <sub>CC</sub> = 12 Vdc, I <sub>C</sub> = 1.0 Adc, I <sub>B1</sub> = I <sub>E</sub>	32 = 100	mAdc)		toff	uct (2) dc, front = 20 MH	100	mico ans ma mico e ans ma
*Indicates JEDEC Registered Data  1) Pulse Test: Pulse Width ≤ 300 µs, Du	ity Cycle	do do	(2) f==	=  h <sub>fe</sub>   ● f <sub>test</sub> .	(x5488.1	tance 'dc, ig = 0, i = 0.'	ingo: Capaci
FIGURE 2 – SWITCHING TIME				10. 1031		- TURN-ON TIM	
	Voc			1000			S181 1 55
	VCC P		-	700	1 0 400 - 20 4		10/10 = 10
35 116	Į.			500	t <sub>r</sub> @ V <sub>CC</sub> = 30 V-	387 10 - 347	- IC/IB = 10/
V <sub>1</sub> 38	₹R <sub>C</sub>	43		300	MAL I		011111 86
0 due R <sub>B</sub>	N			€ 200		20V 15 - 24 V	603 : 62630
V <sub>2</sub>	( )	9.0		100 La 200			607 7 11
t <sub>r</sub> , t <sub>f</sub> < 10 ns 1N916	7		2812067	→ 70			21 48 4 - 1011
DUTY CYCLE = 1.0%	Ŧ	2N3719	2N3867 2N3868	50	td @ VBE(off) = 4.0 V		200 2009
VBB	_	2N3720	2N6303	30	de de (dii) 4.0 v	11111	p1 40 1 42
	VCC RC	-12 V 12 Ω	-30 V 19 Ω	20	111111	1 1 1 1 1 1 1 1 1	
NOTE:	RB	100 Ω	100 Ω	10			
		1	12011	10			
For information on Figures 3 and 6, Rg and RC were varied to obtain desired test conditions.	V <sub>1</sub> V <sub>2</sub>	+8.0 V -11 V	13.6 V -16.4 V	0.03 0.05	0.07 0.1 0.2	0.3 0.5 0.7 1.	.0 2.0

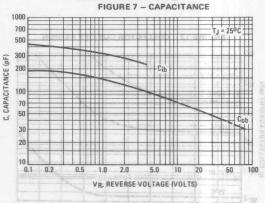




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown, Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{o}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \lesssim 200^{o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





# 2N3738, 2N3739 NPN 2N6424, 2N6425 PNP



2N3738, 2N3739 NPN/2N6424, 2N6425 PNP

# HIGH VOLTAGE COMPLEMENTARY SILICON POWER TRANSISTORS

...designed for high-speed switching, linear amplifier applications, high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

Collector-Emitter Sustaining Voltage —

V<sub>CEO</sub>(sus) = 225 Vdc @ I<sub>C</sub> = 5.0 mAdc (2N3738, 2N6424) = 300 Vdc @ I<sub>C</sub> = 5.0 mAdc (2N3739, 2N6425)

- DC Current Gain
  - hFE = 40-200 @ IC = 100 mAdc
- Current-Gain Bandwidth Product f<sub>T</sub> = 10 MHz (Min) @ I<sub>C</sub> = 100 mAdc
- IS/b Rated to 2.0 Amperes

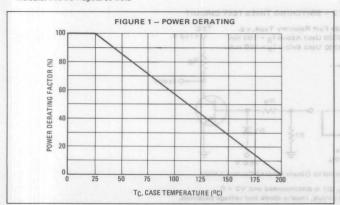
#### \*MAXIMUM RATINGS

Rating	Symbol	2N3738 2N6424	2N3739 2N6425	Unit
Collector-Emitter Voltage	VCEO	225	300	Vdc
Collector-Base Voltage	VCB	250	325	Vdc
Emitter-Base Voltage	VEB	(	5.0	Vdc
Collector Current – Continuous – Peak	· Ic	1.0		Adc
Base Current – Continuous – Peak	IB	0.50		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	20 0.133		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	0+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	7.5	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data

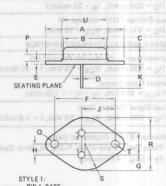


#### 1.0 AMPERE

# POWER TRANSISTORS COMPLEMENTARY SILICON

225, 300 VOLTS 20 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

	MILLI	METERS	IN	INCHES			
DIM	MIN	MAX	MIN	MAX			
В	11.94	12.70	0.470	0.500			
C	6.35	8.64	0.250	0.340			
D	0.71	0.86	0.028	0.034			
E	1.27	1.91	0.050	0.075			
F	24.33	24.43	0.958	0.962			
G	4.83	5.33	0.190	0.210			
Н	2.41	2.67	0.095	0.105			
J	14.48	14.99	0.570	0.590			
K	9.14	-	0.360	-			
P	V-	1.27	-	0.050			
0	3.61	3.86	0.142	0.152			
S	-	8.89	-	0.350			
T	-	3.68	-	0.145			
U	-	15.75	-	0.620			

All JEDEC Dimensions and and Notes Apply.

CASE 80-02

TO-66

Characteristic			Symb	Symbol Min		Max	Unit	
OFF CHARACTERISTICS								
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 5.0 mAdc, I <sub>B</sub> = 0)	2N3738, 2N3739,		VCEO(	Contract.	M3 2	25 00	NATIOV H	Vdc
Collector-Emitter Cutoff Current (V <sub>CE</sub> = 125 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 200 Vdc, I <sub>B</sub> = 0)	2N3738, 2N3739,	2N6424 2N6425	equiators	inear a ching r	tive a	amplifie <del>r</del>	0.25 bar	hic vott
Collector-Base Cutoff Current (V <sub>CB</sub> = 250 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 325 Vdc, I <sub>E</sub> = 0)	2N3738, 2N3739,		СВ	O YOU	obit no	es and hig Venime V	0.1 101 0.1 101	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 250 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 300 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 125 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C) (V <sub>CE</sub> = 200 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)	2N3738, 2N6424 2N3739, 2N6425 2N3738, 2N6424		<b>V</b> obAm	Vdc @ IQ = 5.0 m		0.5 0.5 1.0	qri	
Emitter-Base Cutoff Current (V <sub>EB</sub> = 6.0 Vdc)			IEB	0			0.1 bers	mAdc
ON CHARACTERISTICS								
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc)	JinU Vdc	SNG759 SN6625	2M3138 2M4228 2M6424	lades	8 .	30 40 25	200	MAXIMUM A
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)	361/	325	V <sub>CE</sub> (			_	2.5	Vdc
Base-Emitter "ON" Voltage (1) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc)	Adc	0.	V <sub>BE</sub> (	on)		_	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS	nhul.	0.5	0	w.l			Continuous	- Zena Li Dugan S
Current-Gain — Bandwidth Product (2) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f = 10 MHz)	sera-W	20	fT	0,4		10 5089	Peak saloation B To =	MHz
Output Capacitance (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	Do/M	133	Cob	praT.t		_	20 20 20 101	pF=0
Small-Signal Current Gain			h <sub>fe</sub>					erutare <u>u</u> mali

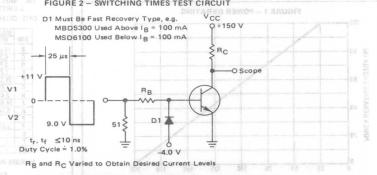
\*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2%.

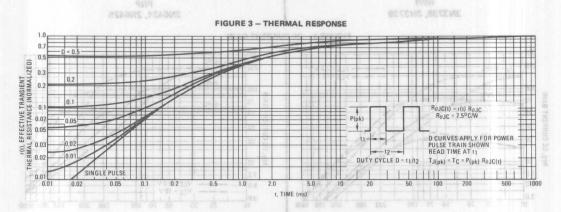
 $(I_C = 100 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 1.0 \text{ kHz})$ 

(2) fT = | hfe | • frequency

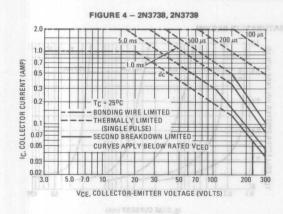


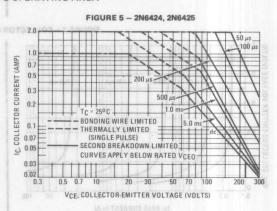


For  $t_d$  and  $t_r$ , D1 is disconnected and V2 = 0 For PNP test circuit, reverse diode and voltage polarities.



### And THERBUS HOTSELDOS ST ACTIVE-REGION SAFE OPERATING AREA





There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C}$  -  $V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 4 and 5 is based on  $T_C=25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 175^{o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 4 and 5 may be found at any case temperature by using the appropriate curve on Figure 1.

IC, COLLECTOR CURRENT (mA)

3-40

IC, COLLECTOR CURRENT (mA)



# MEDIUM-POWER PNP TRANSISTORS

. . . ideal for use as drivers, switches and medium-power amplifier applications. These devices feature:

- Low Saturation Voltage − 0.6 VCE(sat) @ IC = 1.0 Amp
- High Gain Characteristics hFE@ IC = 250 mA: 30-100
- Excellent Safe Area Limits (See Figure 2)
- Low Collector Cutoff Current 100 nA (Max) 2N3740A, 2N3741A
- Complementary to NPN 2N3766 (2N3740) and 2N3767 (2N3741)

### POWER TRANSISTORS

Collegeor Emilias Sustaining Voltage C

PNP SILICON

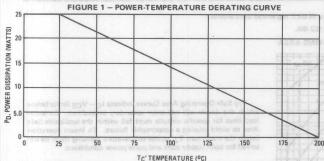
60-80 VOLTS 25 WATTS



#### \*MAXIMUM RATINGS

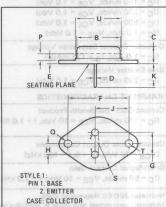
BOV Rating 0.0	Symbol	2N3740 2N3740A	2N3741 2N3741A	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Emitter-Base Voltage	VEB	7.0	7.0	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Collector Current — Continuous — Peak (Note 1)	IC T	The second second	.0	Adc
Base Current	I <sub>B</sub>	2	.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		143	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

Note 1: See Figure 2



Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

\*Indicates JEDEC Registered Data.



00	MILLI	WETERS	IN	CHES
DIM	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	- 1	0.360	-
P	1-	1.27	-	0.050
0	3.61	3.86	0.142	0.152
S	-	8.89	-	0.350
T	-	3.68	424	0.145
U	72	15 75	30 THE	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02 (TO-66)

# \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)		3740, 2N3740A 3741, 2N3741A	VCEO(sus)	60 80	_	Vdc
Emitter Base Cutoff Current			IEBO			
(V <sub>EB</sub> = 7.0 Vdc)		3740, 2N3741 3740A, 2N3741A	·EBO	-	0.5 100	mAdc nAdc
Collector Cutoff Current			ICEX			
(V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc)		2N3740 2N3740A	WER PNP TRAI	- UNHPO	100	μAdc nAdc
(V <sub>CE</sub> = 80 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)		2N3741 2N3741A		_	100 100	μAdc nAdc
(V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150		2N3740 2N3740A	rs, switches and m	es drive	1.0	mAdc
(V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150 <sup>o</sup>	PC)	2N3741 2N3741A		de <u>v</u> ices	1.0 0.5	mAdc
Collector-Emitter Cutoff Current		Ic = 1.0 Amp	INICEO OU -	Voltage	Saturation	wed s
(V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)		2N3740	s - hr g@ 1c = 25	pete <del>r</del> istid	Ga O. Char	mAdc
		2N3740A	its (See Figure 2)	mid sanA	1.0	μAdc
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)		2N3741 2N3741A	- inem		1.0	mAdc μAdc
Collector Base Cutoff Current			ІСВО	ATEMS ()	shi) An 90	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)		2N3740	2N3786 (2N3740		100	μAdc
W. CONT. TO STATE OF		2N3740A		-	100	nAdc
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)		2N3741 2N3741A		-	100 100	μAdc nAdc
		2N3741A		_	100	nAdc
ON CHARACTERISTICS						
DC Current Gain			hFE(1)			
(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 1.0 Vdc)				40	-	
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc)				30	100	
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)				20	ATHNESS	A MUM
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)				10		
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 125 mAdc)	tinti	APALEME AN	VCE (sat) 1	-	0.6	Vdc
Base-Emitter Voltage	Vac	08 1	V <sub>BE(1)</sub>		1.0	Vdc
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc)			32.0		/oftage	ses8-sati
TRANSIENT CHARACTERISTICS	obA	4.0	16 83V	211011	vorege ont - Continu	mili v Sim
Current-Gain-Bandwidth Product		10.	fT	loss 1)	1) stag9 -	MHz
(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)			BI	3.0	-	men 3
	Mark	30	90	4.01	in collection (in	Loubs CL
Common Base Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>C</sub> = 0, f = 100 kHz)		0.143	Cob	-	100	pF
	20	-85 to +200	032 <sup>T</sup> -L <sup>T</sup>	noin		bas griver
Small-Signal Current Gain			hfe	25	mensh :	um and the

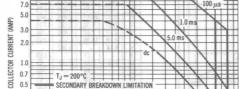
0.5

0.2

2N3741.A-

20 30

FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA



SECONDARY BREAKDOWN LIMITATION

5.0 7.0 10

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

-- THERMAL LIMITATION - RASE-EMITTER DISSIPATION IS - SIGNIFICANT ABOVE I<sub>C</sub> = 2.0 AMP) - PULSE DUTY CYCLE \( \leq 10\% \)

3.0

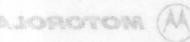
50 70 100

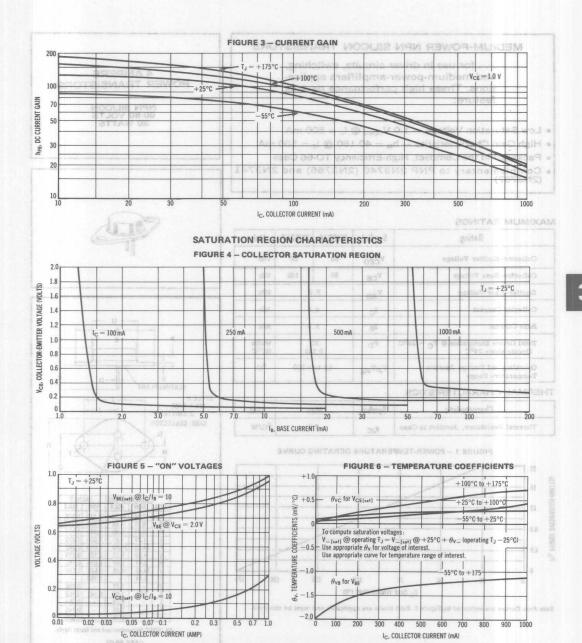
The Safe Operating Area Curves indicate I  $_{\rm C}$  – V $_{\rm CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.

<sup>\*</sup>Indicates JEDEC Registered Data.

†Motorola guarantees this value in addition to the JEDEC registered data shown.

① Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤2.0%.







# MEDIUM-POWER NPN SILICON TRANSISTORS

. . . for use in driver circuits, switching. and medium-power-amplifiers applications. These high performance devices feature:

- Low Saturation Voltage  $-1.0 \text{ V}_{\text{CE[sat]}}$  @  $I_{\text{C}} = 500 \text{ mA}$
- High Gain Characteristics he = 40-160 @ Ic = 500 mA
- · Packaged in the Compact, High-Efficiency TO-66 Case
- Complementary to PNP 2N3740 (2N3766) and 2N3741 (2N3767)

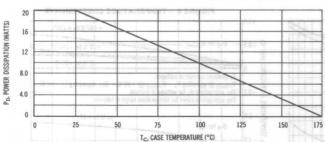
#### MAXIMUM RATINGS

Rating	Symbol	2N3766	2N3767	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	60	80	Vdc
Collector-Base Voltage	v <sub>CB</sub>	80	100	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	6.	0	Vdc
Collector Current	I <sub>C</sub>	4	. 0	Adc
Base Current	IB	2	. 0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	0.1	0	Watts W/OC
Operating and Storage Junction Temperature Range	$T_J$ , $T_{stg}$	-65 to	+200	°c

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	7.5	°C/W

### FIGURE 1 - POWER-TEMPERATURE DERATING CURVE

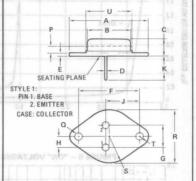


Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

# 4 AMPERE POWER TRANSISTORS

NPN SILICON 60-80 VOLTS 20 WATTS





10	MILLI	METERS	IN	CHES
MIC	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
Н	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	-	0.360	-
P	-	1.27	1-1	0.050
0	3.61	3.86	0.142	0.152
S	-	8.89	-	0.350
T	u =	3.68	-	0.145
U		15.75		0.620

All JEDEC Dimensions and and Notes Apply. CASE 80-02

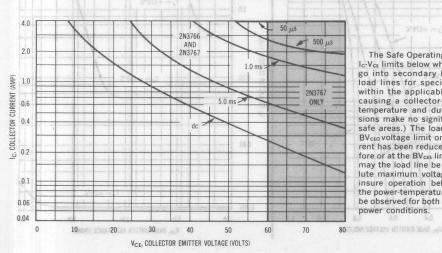
# 3

# ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
F CHARACTERISTICS	I — A SHUUR		SUMATO	UQNOSANARI	- S SHUDIT	
Collector-Emitter Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N3766 2N3767		BV <sub>CEO</sub>	60 80		Vdc
Emitter-Base Cutoff Current (V <sub>EB</sub> = 6.0 Vdc)	V 04 = 40 V		I <sub>EBO</sub>	77-1	0.75	mAdc
Collector Cutoff Current ( $V_{CE}$ = 80 Vdc, $V_{BE}$ = 1.5 Vdc) ( $V_{CE}$ = 100 Vdc, $V_{BE}$ = 1.5 Vdc)	2N3766 2N3767		I <sub>CEX</sub>	1	0.1 0.1	mAdc
$(V_{CE} = 50 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_{C} = 15)$ $(V_{CE} = 70 \text{ Vdc}, V_{BE} = 1.5 \text{ Vdc}, T_{C} = 15)$	50°C) 2N3766 50°C) 2N3767			\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	1.0	
Collector-Emitter Cutoff Current (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 80 Vdc, I <sub>B</sub> = 0)	2N3766 2N3767	14 (44A)	ICEO		0.7	mAdc
Collector-Base Cutoff Current (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N3766	1 8 1	<sup>I</sup> СВО	1-1-1-	0.1	mAdc
$(v_{CB} = 100 \text{ Vdc}, I_E = 0)$	2N3767	3 4 4 1		1 1	0.1	
CHARACTERISTICS		d 81				01
DC Current Gain (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 5.0 Vdc)			$h_{ m FE}$	30		
$(I_C = 500 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc})$ $(I_C = 1.0 \text{ Adc}, V_{CE} = 10 \text{ Vdc})$				40	160	
Collector-Emitter Saturation Voltage ( $I_C = 1.0 \text{ Adc}$ , $I_B = 0.1 \text{ Adc}$ ) ( $I_C = 500 \text{ mAdc}$ , $I_B = 50 \text{ mAdc}$ )	ua 3883V3R — ★→		V <sub>CE(sat)</sub>		2.5	Vdc
Base-Emitter Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc)	125 = 425		V <sub>BE</sub>		1.5	Vdc
RANSIENT CHARACTERISTICS		100.0			4-4-1	0)
Current-Gain - Bandwidth Product (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f = 10 M	MHz)	ē.0.	f <sub>T</sub>	BOAT JOY 10 TIMO	12 B .00 - Vec. B 121	MHz
Common-Base Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>C</sub> = 0 Adc, f = 100 kHz	)-19457_3 #RUD	151	Cob	MIA TIMAL	50	pF
Small-Signal Current Gain (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0	kHz)		h <sub>fe</sub>	40	1-1-1	- 1 10

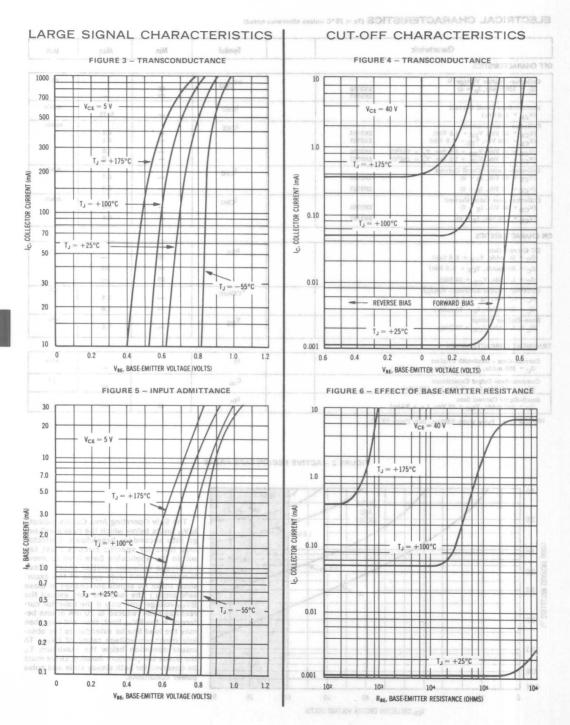
(1) Pulse Test: Pulse Width  $\leq 300 \mu s$ , Duty Cycle  $\leq 2.0\%$ .

# FIGURE 2 - ACTIVE REGION SAFE AREAS

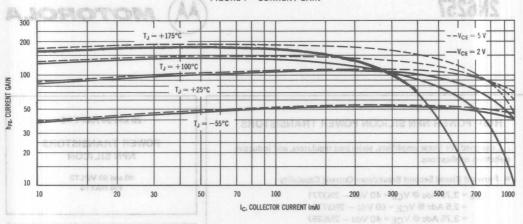


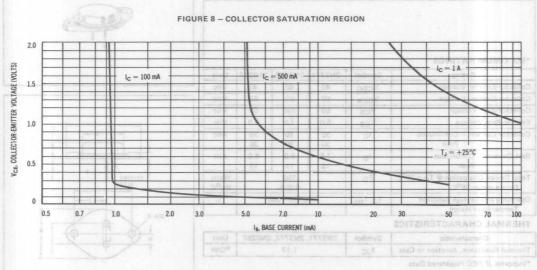
The Safe Operating Area Curves indicate Ic-Vcs limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BVcso voltage limit only if the collector current has been reduced to 20 mA or less before or at the BVcs limit; then and only then may the load line be extended to the absolute maximum voltage rating of BVcso. To insure operation below the maximum T, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

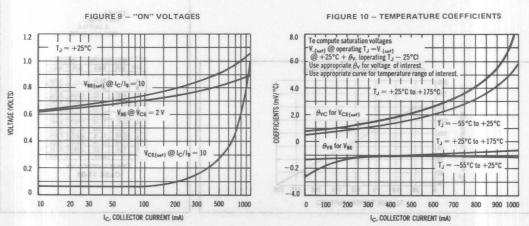














# HIGH POWER NPN SILICON POWER TRANSISTORS

 $\dots$  designed for linear amplifiers, series pass regulators, and inductive switching applications.

Forward Biased Second Breakdown Current Capability

IS/b = 3.75 Adc @ VCE = 40 Vdc - 2N3771

= 2.5 Adc @ V<sub>CE</sub> = 60 Vdc - 2N3772

= 3.75 Adc @ VCE = 40 Vdc - 2N6257

20 and 30 AMPERE

POWER TRANSISTORS
NPN SILICON

40 and 60 VOLTS 150 WATTS



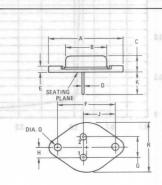
#### \*MAXIMUM RATINGS

Rating	Symbol	2N3771	2N3772	2N6257	Unit
Collector-Emitter Voltage	VCEO	40	60	40	Vdc
Collector-Emitter Voltage	VCEX	50	80	50	Vdc
Collector-Base Voltage	VCB	50	100	50	Vdc
Emitter-Base Voltage	VEB	5.0	7.0	5.0	Vdc
Collector Current — Continuous Peak	IC	30 30	20 30	20 30	Adc
Base Current — Continuous Peak	I <sub>B</sub>	7.5 15	5.0 15	5.0 15	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		150 0.855		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	65 to +20	tarke a security	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3771, 2N3772, 2N6257	Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W

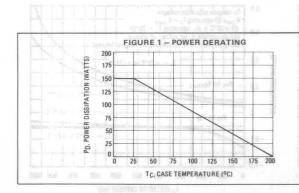
<sup>\*</sup>Indicates JEDEC Registered Data



STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR

H	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	1-14	39.37		1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67	- 1	1.050

CASE 11-01

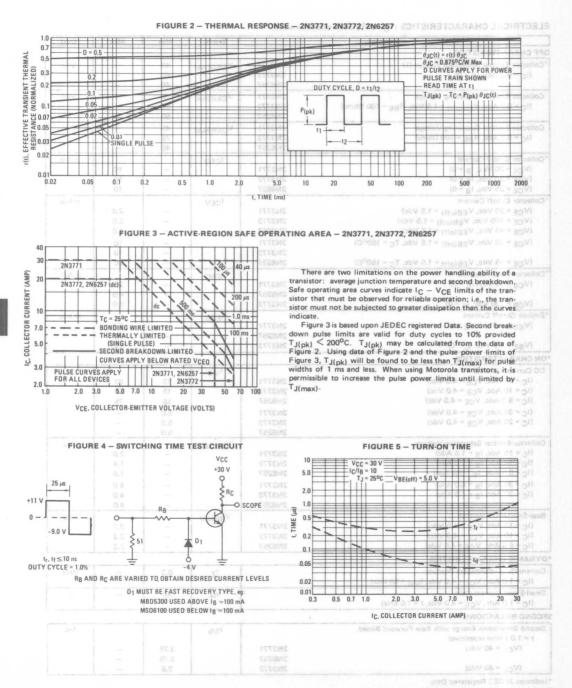


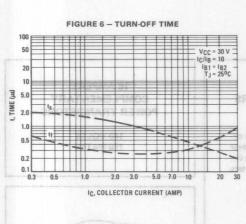
# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

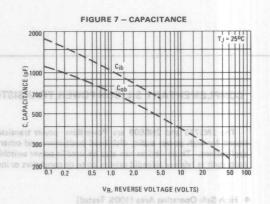
Characteristic Characteristic	The second	Symbol	Min	Max	Unit
	0110774		40		T w
Collector-Emitter Sustaining Voltage (1)	2N3771	VCEO(sus)	40		Vdc
(I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)	2N3772		60	11	
OUTVICATOR OF PARTS AND THE ALTH	2N6257	- 1000	40		
Collector-Emitter Sustaining Voltage	2N3771	VCEX(sus)	50	The same of the same	Vdc
(I <sub>C</sub> = 0.2 Adc, V <sub>EB(off)</sub> = 1.5 Vdc, R <sub>BE</sub> = 100 Ohms)	2N3772		80		10-1-
	2N6257		50		NATE OF
Collector-Emitter Sustaining Voltage	2N3771	VCER(sus)	45		Vdc
(I <sub>C</sub> = 0.2 Adc, R <sub>BE</sub> = 100 Ohms)	2N3772	CLITISUS	70	100	Har-Hi
	2N6257		45	na antikus	
Collector Cutoff Current		loss			mAdc
(V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)	2N3771	CEO		10	MAGC
(Vor = 50 Vdc In = 0)	2N3772			10	
(V <sub>CE</sub> = 25 Vdc, I <sub>B</sub> = 0)	2N6527	1.0 0.7	2.0	10	10.8
	2100527			10	-
Collector Cutoff Current		CEV			mAdc
(V <sub>CE</sub> = 50 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc)	2N3771		-	2.0	
(V <sub>CE</sub> = 100 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc)	2N3772	W	-	5.0	
(V <sub>CE</sub> = 45 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc)	2N6257	E-REGION S	STORT BE	4.0	
(V <sub>CE</sub> = 30 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N3771			10	
	2N3772		- 1	10	
(VCE = 45 Vdc, VEB(off) = 1.5 Vdc, TC = 150°C)	2N6527	1 100-	1771-711	20	STATE OF
Collector Cutoff Current	HIT III	lone	1111		mAdc
(V <sub>CB</sub> = 50 Vdc, I <sub>E</sub> = 0)	2N3771	СВО		2.0	MAGC
on the state of the transfer o	2N6257	114 4			
(V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)	1 701515 1110000000000000000000000000000	INS.		4.0	
THE PARTY OF THE PARTY PARTY PARTY OF THE PA	2N3772	1 1 1	82 T N.	5.0	
Emitter Cutoff Current		IEBO			mAdc
(VBE = 5.0 Vdc, IC = 0) harmon 2 dat noon bank at any			P - 051901.1	5.0	THE R. LEW
pulse limits are valid for duty system to 10% promod-	2N6257	1	-111111	10	A 20 11 11 11 11
(V <sub>BE</sub> = 7.0 Vdc, I <sub>C</sub> = 0)	2N3772	7771	STATE AND THE	5.0	
ON CHARACTERISTICS					
DC Current Gain (1) Att sloward golden aget to age bra an T to	cities it	hFE	man recount I	1 1 191a	erveus — my
(IC = 15 Adc, VCE = 4.0 Vdc)	2N3771	Section of the	15	60	100 Li 50
	2N3772	5 02 92	05 15 51	60	0.5
(I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N6257		15	75	
(I <sub>C</sub> = 30 Adc, V <sub>CE</sub> = 4.0 Vdc)		vacrar	THE WAY TAKE	TIKO-RETORUL	00 apv
	2N3771	The second	5.0	-	Term !
(I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N3772		5.0	-	4.37
	2N6257		5.0	_	-
Collector-Emitter Saturation Voltage		VCE(sat)	LEMMA DANK	A - SWITCH	Vdc
(I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 1.5 Adc)	2N3771	30V	-	2.0	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc)	2N3//2	W 00*	-	1.4	
(I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 0.8 Adc)	2N6257		-	1.5	
(I <sub>C</sub> = 30 Adc, I <sub>B</sub> = 6.0 Adc)	2N3771		-	4.0	100
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 4.0 Adc)	2N3772	388		4.0	
	2N6257	0		4.0	
Base-Emitter On Voltage	8.0 %	VBE(on)			Vdc
(I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N3771	, BE(OU)	_	2.7	N. C.
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N3771	1		2.7	70
(I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N6257	10		2.2	
	2140207			2.2	1
DYNAMIC CHARACTERISTICS	20.0	with the state of	2	100	S 4 8 30 1(2
Current-Gain—Bandwidth Product		fT	0.2		MHz
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f <sub>test</sub> = 50 kHz)		MARRIED CONRECT	UNIATED DT C		WA gr
Small-Signal Current Gain	10.0	h <sub>fe</sub>	40	185 y G	1 -
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 kHz)	.0	mast- at avea	RDSSOO DEED A		
ECOND BREAKDOWN NO 1935 807 33 1993 31		to cor- griffour	Date out the	di-	_
Second Breakdown Energy with Base Forward Biased,		Is/b			Adc
t = 1.0 s (non-repetitive)					
(V <sub>CE</sub> = 40 Vdc)	2N3771		3.75	-	
	2N6257		2.75		
(V <sub>CE</sub> = 60 Vdc)	2110257		3.75	-	

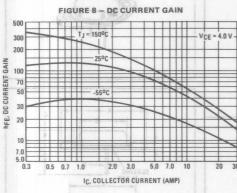
<sup>\*</sup>Indicates JEDEC Registered Data (1) Pulse Test: 300 µs, Rep. Rate 60 cps.

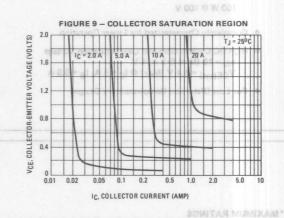












1			N	0.4
13			3	1
13	2		18	
1-8	-			1
	1			
		-0-		
	1	1		
			STYLE	
		BASE .		
	8013	11103 3		
mag a				
				A 0 0
				A 60 00
				A 60 00
				A (C) (C) (C) (M)
193.0 195.0 191.0 191.0 191.1				A (C) (C) (C) (M)
193.0 195.0 191.0 191.0 191.1				A (C) (C) (C) (M)
193.0 195.0 191.0 191.0 191.1				A (C) (C) (C) (M)
193.0 195.0 191.0 191.0 191.1				A (C) (C) (C) (M)
602.0 602.0 761.0 761.0 761.1 761.1 761.1 761.1 761.1 761.1				A 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
100.0 100.0 101.0 101.0 701.1				A 40 (2) (2) (4)

		Value	
Collector Emitter Valsage			Vide
Collect or-Emiliar Voluge	хаом		
Coffectat Back Voltage		160	
Emitter-Basa Voltage			
Collector Current — Continuous — Pilek (1)	0	87 08	
Base Connair - Continuous Puas (1)		8 2r	
Total Pairer Dissipation © Tg = 25°C Carate acove 25°C	99	160	Watts WOC
Operating are Storage Junation Temperature Range	gap T .LT	-86 to 4200	
THERMAL THARACTERISTICS			
Characteristic	Symbol	Nox	
Thermal Resistance, Junction to Case	DCeFF		

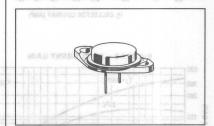
3-51

The 2N3773 and 2N6609 are PowerBase power transistors designed for high power audio, disk head positioners and other linear applications. These devices can also be used in power switching circuits such as relay or solenoid drivers, dc to dc converters or inverters.

- High Safe Operating Area (100% Tested)
   150 W @ 100 V
- Completely Characterized for Linear Operation
- High DC Current Gain and Low Saturation Voltage hfe = 15 (Min) @ 8 A, 4 V VCE(sat) = 1.4 V (Max) @ I<sub>C</sub> = 8 A, I<sub>B</sub> = 0.8 A
- For Low Distortion Complementary Designs

16 AMPERE
COMPLEMENTARY
POWER TRANSISTORS

140 VOLTS 150 WATTS



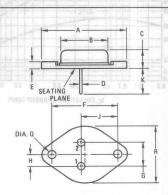


*MAXIMUM RATINGS			
Rating	Symbol	Value	Unit
Collector Emitter Voltage	VCEO	140	Vdc
Collector-Emitter Voltage	VCEX	160	Vdc
Collector-Base Voltage	V <sub>CBO</sub>	160	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector Current — Continuous — Peak (1)	lc	16 30	Adc
Base Current — Continuous — Peak (1)	IB	4 15	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	150 0.855	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C
THERMAL CHARACTERISTICS			
Characteristic	Symbol	Max	Unit

 $R_{\theta}JC$ 

Thermal Resistance, Junction to Case
\*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR

	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	-	39.37	_	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
B	-	26 67	_	1.050

Collector connected to case. CASE 11-01 (TO-3)

3

1.17

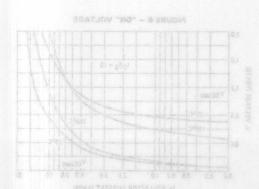
°C/W

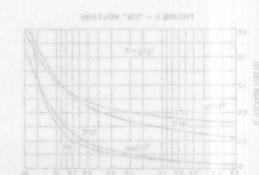
#### ELECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS (1)			27.10.1	
"Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)	VCEO(sus)	140	nu p = pc eur	Vdc Vdc
*Collector-Emitter Sustaining Voltage (IC = 0.1 Adc, VBE(off) = 1.5 Vdc, RBE = 100 Ohms)	VCEX (sus)	160	1 - 11	Vdc
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 0.2 Adc, R <sub>BE</sub> = 100 Ohms)	VCER(sus)	150		Vdc
*Collector Cutoff Current (V <sub>CE</sub> = 120 Vdc, I <sub>B</sub> = 0)	ICEO		10	mAdc
*Collector Cutoff Current (V <sub>CE</sub> = 140 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 140 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEX		2 10	mAdc
Collector Cutoff Current (VCB = 140 Vdc, IE = 0)	ІСВО		2	mAdc
*Emitter Cutoff Current (V <sub>BE</sub> = 7 Vdc, I <sub>C</sub> = 0)	IEBO	HILL	5	mAdc
ON CHARACTERISTICS (1)				
DC Current Gain *(I <sub>C</sub> = 8 Adc, V <sub>CE</sub> = 4 Vdc) (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 4 Vdc)	hFE	15 5	60	-
Collector-Emitter Saturation Voltage  *(I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 800 mAdc)  (I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 3.2 Adc)	VCE(sat)	MOTTARATION	1.4	Vdc
*Base-Emitter On Voltage (I <sub>C</sub> = 8 Adc, V <sub>CE</sub> = 4 Vdc)	V <sub>BE(on)</sub>		2.2	Vdc
DYNAMIC CHARACTERISTICS				
Magnitude of Common-Emitter Small-Signal, Short-Circuit, Forward Current Transfer Ratio (I <sub>C</sub> = 1 A, f = 50 kHz)	Ih <sub>fe</sub> I	4		
*Small-Signal Current Gain (IC = 1 Adc, VCE = 4 Vdc, f = 1 kHz)	h <sub>fe</sub>	40	1/71	
SECOND BREAKDOWN CHARACTERISTICS				
Second Breakdown Collector Current with Base Forward Blased t = 1 s (non-repetitive), V <sub>CE</sub> = 100 V, See Figure 12	Is/b	1.5	111	Adc

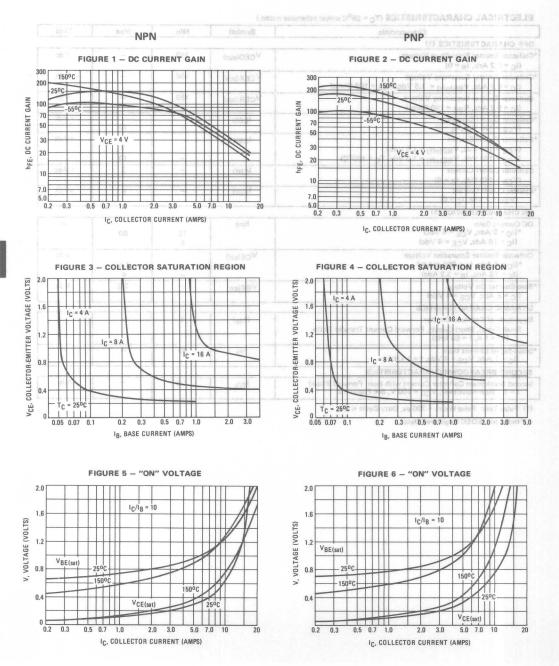
<sup>(1)</sup> Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.

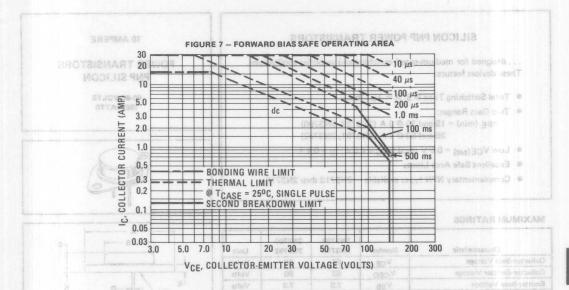
<sup>\*</sup>Indicates JEDEC Registered Data





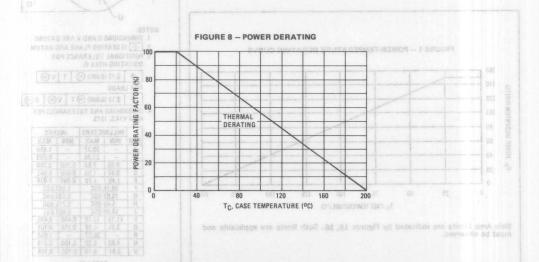






There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation: i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on  $T_J(p_k)$  =  $200^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 200^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. TJ, Tetg





# SILICON PNP POWER TRANSISTORS

... designed for medium-speed switching and amplifier applications. These devices feature:

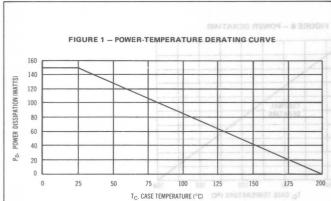
- Total Switching Time @ 3 A  $\approx$  1  $\mu$ s (typ)
- Two Gain Ranges:

hFE (min) = 15 and 30 @ 3 A (2N3789, 2N3790) 25 and 50 @ 1 A (2N3791, 2N3792)

- Low VCE(sat) = 0.5 V (typ) @ IC = 4.0 A, IB = 0.4 A
- Excellent Safe Area Limits
- Complementary NPN types available 2N3713 thru 2N3716

# **MAXIMUM RATINGS**

Characteristic 005 0	Symbol	2N3789 2N3791	2N3790 2N3792	Unit
Collector-Base Voltage	V <sub>CB</sub>	60	80	Volts
Collector-Emitter Voltage	VCEO	60	80	Volts
Emitter-Base Voltage	VEB	7.0	7.0	Volts
Collector Current (Continuous)	lc	10	10	Amps
Base Current (Continuous)	I <sub>B</sub>	4.0	4.0	Amps
Power Dissipation 2005 > 1201 T be	PD	150	150	Watts
Thermal Resitance	θJC	1.17	1.17	°C/W
Junction Operating and Storage Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	o +200	°C



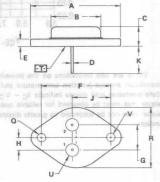
Safe Area Limits are indicated by Figures 15, 16. Both limits are applicable and must be observed.

# 10 AMPERE

# **POWER TRANSISTORS** PNP SILICON

**60-80 VOLTS** 150 WATTS





- 1. DIMENSIONS Q AND V ARE DATUMS.
  2. T. IS SEATING PLANE AND DATUM. 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
- ♦ 0.13 (0.005) M T V M

FOR LEADS:

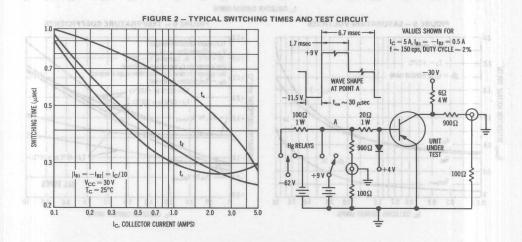
- ♦ 0.13 (0.005) M T VM QM
- DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

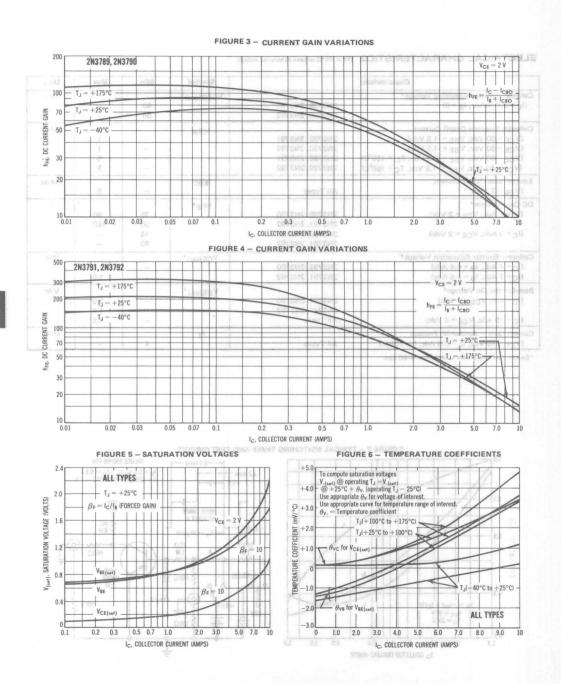
	MILLIN	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15 BSC		1.187	7 BSC	
G	10.92 BSC		0,430 BSC		
Н	5.46	BSC	0.215 BSC		
J	16.89	16.89 BSC		BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

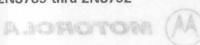
# ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage*		VCEO(sus)*		2011	Vdc
(I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N3789, 2N3791		60		11 45
	2N3790, 2N3792		80	Tresson Land	1 8
Collector-Emmiter Cutoff Current		ICEX		20-	mAdd
(V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> = -1.5 Vdc)	2N3789, 2N3791		-	1	- 기 및
(V <sub>CE</sub> = 80 Vdc, V <sub>BE</sub> = -1.5 Vdc)	2N3790, 2N3792		-	1	1 1
(V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> = -1.5 Vdc, T <sub>C</sub> = 150°C)	2N3789, 2N3791			5	1 1 10 1
(V <sub>CE</sub> = 80 Vdc, V <sub>BE</sub> = -1.5 Vdc, T <sub>C</sub> = 150°C)	2N3790, 2N3792			5	
Emitter-Base Cutoff Current		IEBO			mAdd
(V <sub>EB</sub> = 7 Vdc)	All Types			5	
DC Current Gain*		hFE*			_
(I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 2 Vdc)	2N3789, 2N3790		25	90	Liga .
	2N3791, 2N3792	1.0 20.0 %	50	180	10.0
(I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2 Vdc)	2N3789, 2N3790		15	-	1981
	2N3791, 2N3792	29 (1D) S	30	-	
Collector-Emitter Saturation Voltage*		VCE(sat)*			Vdc
(I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.4 Adc)	2N3789, 2N3790		-	1.0	
(I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc)	2N3791, 2N3792		-	1.0	1000000
Base-Emitter On Voltage*		VBE(on)*		distribution of	Vdc
(IC = 5 A, VCE = 2 Vdc)	2N3789, 2N3790		- 0	2.0	205 100
The state of the s	2N3791, 2N3792		errepri <del>a</del> repris	1.8	
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4 Vdc)	All Types		- 3	4.0	
Current Gain - Bandwidth Product		fT			MHz
(VCE = 10 Vdc, IC = 0.5 Adc, f = 1 MHz)	All Types		4		三 加

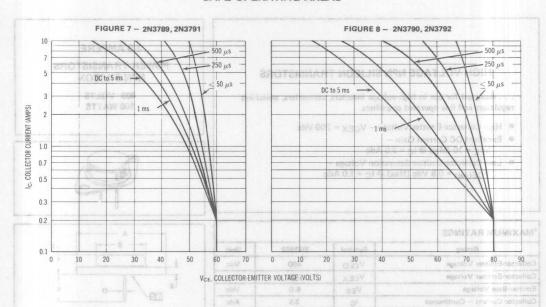
<sup>\*</sup>Sweep Test: 1/2 sine wave cycle @ 60 cps





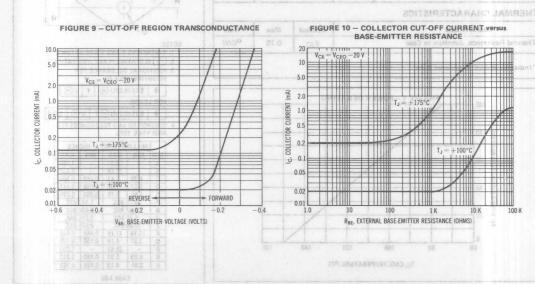


#### SAFE OPERATING AREAS



The Safe Operating Area Curves indicate Ic - VCE limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum TJ, the power-temperature derating curve must be observed for both steady state and pulse power conditions.



# HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage VCEX = 700 Vdc
- Excellent DC Current Gain —
   hFE = 10 (Min) @ IC = 2.5 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.8 Vdc (Max).@ IC = 1.0 Adc

# 3.5 AMPERE

# POWER TRANSISTORS NPN SILICON

400 VOLTS 100 WATTS



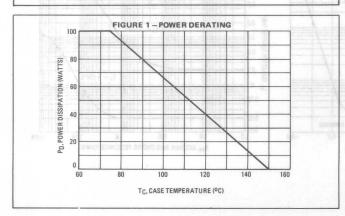
### \*MAXIMUM RATINGS

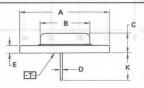
MAXIMOM NATINGS			
Rating	Symbol	2N3902	Unit
Collector-Emitter Voltage	VCEO	400	Vdc
Collector-Emitter Voltage	VCEX	700	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	Ic	3.5	Adc
Base Current	IB	2.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 75°C  Derate above 75°C	PD	100	Watts W/OC
Operating Junction Temperature Range	lud bnergieta y	-65 to +150	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +200	°C

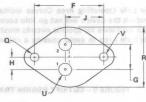
#### THERMAL CHARACTERISTICS

Characteristic 100 100 100 100 100	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.75	°C/W

\*Indicates JEDEC Registered Data







#### NOTES:

- 1. DIMENSIONS Q AND V ARE DATUMS.
- 2. T. IS SEATING PLANE AND DATUM.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
  - ♦ 0.13 (0.005) M T V M

4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

4	MILLIN	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
Α	-	39.37	-	1.550	
В	-	21.08	-	0.830	
C	6,35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15	BSC	1.18	7 BSC	
G	10.92	BSC	0.430	0 BSC	
Н	5.46	5.46 BSC 0.215		5 BSC	
J	16.89	3.89 BSC 0.6		BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

**CASE 1-05** 

MHz

*ELECTRICAL CHARACTERISTICS	(T <sub>C</sub> = 25°C unless otherwise noted)
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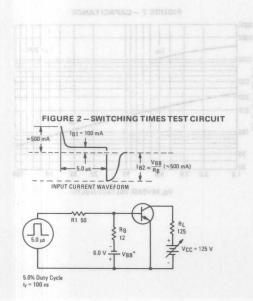
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		1,12	ZITTE	100 100 100 100 100 100 100 100 100 100
Collector-Emitter Sustaining Voltage (IC = 100 mAdc, IB = 0) (See Figure 12)	VCEO(sus)	325		Vdc
Collector Cutoff Current (VCE = 400 Vdc, IB = 0)	ICEO	0.25		mAdc
Collector Cutoff Current (V <sub>CE</sub> = 700 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 400 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	ICEX	0.2 _0.3	2.5 0.5	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	IEBO	_	5.0	mAdc
ON CHARACTERISTICS (1)				1.3
DC Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 5.0 Vdc)	hFE SAU	30	90	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc) (I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> - 0.5 Adc)	VCE(sat)	1/12	0.8 2.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> - 0.1 Adc) (I <sub>C</sub> 2.5 Adc, I <sub>B</sub> 0.5 Adc)	V <sub>BE(sat)</sub>	7 - 3°0	1.5 2.0	Vdc

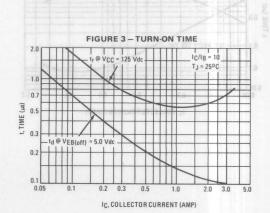
fT

2.8

Current-Gain—Bandwidth Product
(IC = 0.2 Adc, VCE = 10 Vdc)
\*Indicates JEDEC Registered Data

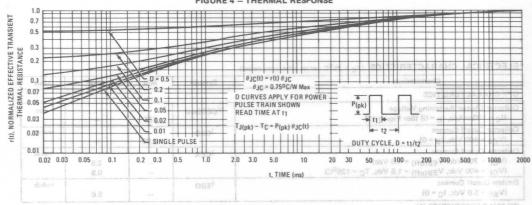
DYNAMIC CHARACTERISTICS



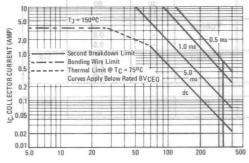


<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.





#### FIGURE 5 - ACTIVE-REGION SAFE-OPERATING AREA



VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

# There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C$ — $V_C$ E limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_J(p_k) = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided  $T_{J(pk)} \le 150^{\circ}$ C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

#### FIGURE 6 - TURN-OFF TIME

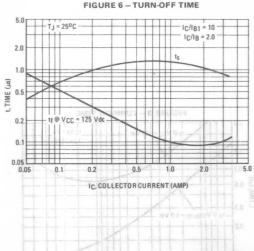
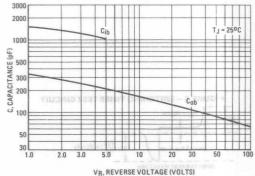
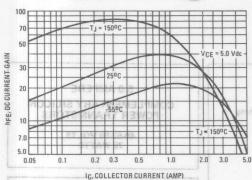


FIGURE 7 - CAPACITANCE



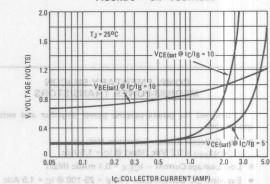


MOTOROLA

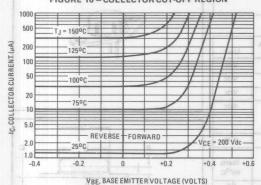


#### FIGURE 9 - "ON" VOLTAGES

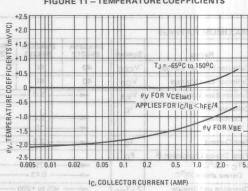
2M4231A thru 2M4233A NPN



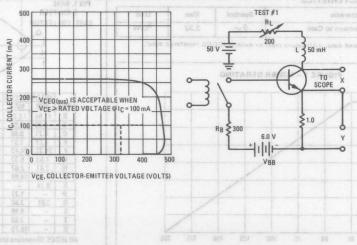
#### FIGURE 10 - COLLECTOR CUT-OFF REGION



### FIGURE 11 - TEMPERATURE COEFFICIENTS



### FIGURE 12 - COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUITS AND LOAD LINES



## COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.7 Vdc (Max) @ IC = 1.5 Adc
- Low Leakage Current ICEX = 0.1 mAdc (Max)
- Excellent DC Current Gain hFE = 25-100 @ IC = 1.5 Adc
- High Current Gain Bandwidth Product fT = 4.0 MHz @ IC = 0.25 Adc

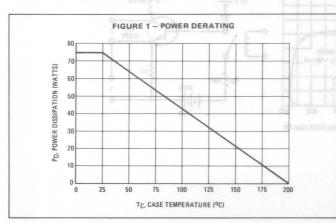
#### \*MAXIMUM RATINGS

		2N4231A	2N4232A	2N4233A	
Rating	Symbol	2N6312	2N6313	2N6314	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	5.0 —	-	Vdc
Collector Current — Continuous Peak	lc	1	5.0 10	BENTE DE	Adc
Base Current	IB	-	2.0 —	H →	Adc
Total Device Dissipation @  T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD		—— 75 —— —— 0.43 ——	<u></u>	Watts W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +200	-	°C

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	2.32	°C/W

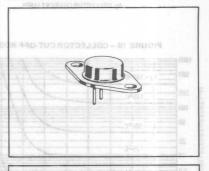
<sup>\*</sup>Indicates JEDEC registered data. (All values meet or exceed JEDEC registered data).

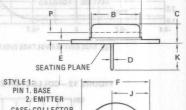


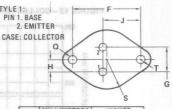
#### 5.0 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

40-60-80 VOLTS 75 WATTS







	MILLI	METERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
Н	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	-	0.360	-
P	-	1.27	-	0.050
Q	3.61	3.86	0.142	0.152
S	-	8.89	_	0.350
T	-	3.68	-	0.145
U	-	15.75	-	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02

TO-66

### 2N4231A thru 2N4233A NPN, 2N6312 thru 2N6314 PNP

Characteristic		Min	Max	Unit
2N4231A, 2N6312	VCEO(sus)	40	_	Vdc
2N4232A, 2N6313 2N4233A, 2N6314		60 80		
2N4231A, 2N6312 2N4232A, 2N6313 2N4233A, 2N6314	ICEO		1.0 1.0 1.0	mAdc
	2N4231A, 2N6312 2N4232A, 2N6313 2N4233A, 2N6314 2N4231A, 2N6312 2N4232A, 2N6313	2N4231A, 2N6312 2N4232A, 2N6313 2N4233A, 2N6314 2N4233A, 2N6314 2N4231A, 2N6312 2N4232A, 2N6313	2N4231A, 2N6312	2N4231A, 2N6312

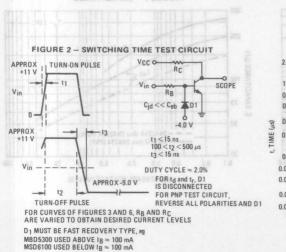
OL D			A CONTRACTOR OF THE PARTY OF TH		
Collector Cutoff Current		ICEX	The state of the s	Trinks I	mAdc
(VCE = 40 Vdc, VBE(off) = 1.5 Vdc)	2N4231A, 2N6312		The same of	0.1	The mond of
(VCE = 60 Vdc, VBE(off) = 1.5 Vdc)	2N4232A, 2N6313		Hart-Page	0.1	26 men (10 S
(VCE = 80 Vdc, VBE(off) = 1.5 Vdc)	2N4233A, 2N6314		-	0.1	The state of the s
(V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N4231A, 2N6312			1.0	
(V <sub>CE</sub> = 60 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N4232A, 2N6313			1.0	2 11
(V <sub>CE</sub> = 80 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N4233A, 2N6314		- 38	1.0	suo i
Collector Cutoff Current		I <sub>CBO</sub>			mAdc
(VCB = 40 Vdc, IE = 0)	2N4231A, 2N6312	72 15 11 1	8.2 - 6.3	0.05	0 811 18.0
(VCB = 60 Vdc, IE = 0)	2N4232A, 2N6313	The same of the same of	-	0.05	
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N4233A, 2N6314	n) 37617 )		0.05	
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	_	0.5	mAdc

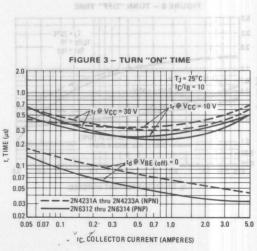
DC Current Gain (1)	DIA THE WA	6 BRUDIR		1-11-11
*(IC = 0.5 Adc, VCE = 2.0 Vdc)		40	-	100 mm
*(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		25	100	
*(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 2.0 Vdc)		10	Janes Janes Hall	7.0000000000000000000000000000000000000
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	Lan Lal	4.0		5.0
*Collector-Emitter Saturation Voltage (1)	VCE(sat)	71 7	7	Vdc
(Ic = 15 Adc Ip = 0.15 AGC)	- HITTOT	7 7 7	0.7	The state of
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.3 Adc)	1 xm 80 X 12		2.0	L Jose
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.25 Adc)		1 -1 10	4.0	
*Base-Emitter On Voltage (1)	VBE(on)	111		Vdc
(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		7 7 -	1.4	· 第一個一個

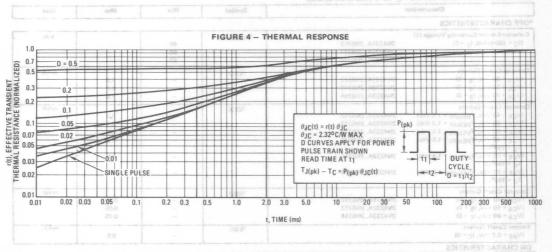
and the state of t	The second second	The same of the same	THE WATER WATER OF THE PARTY OF	AND THE RESERVE
DYNAMIC CHARACTERISTICS	HHA	The Paston	DUDG WARE CHICKEN	ADD
Current-Gain — Bandwidth Product (IC = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	ft //	4.0	AMAL LIMITATION &	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	C <sub>ob</sub>	1000 - 1000	300	pF S.U
Small-Signal Current Gain (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>fe</sub>	20	ACIDARS I	D: 03

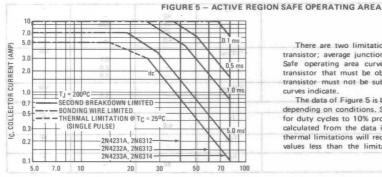
<sup>\*</sup>Indicates JEDEC registered data.

<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.





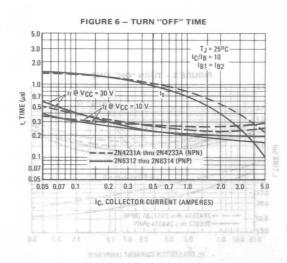


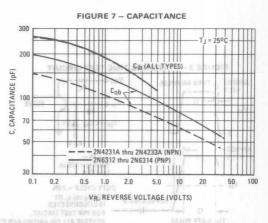


There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate  $I_{C}-V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}$  = 200°C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^{\circ}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown.



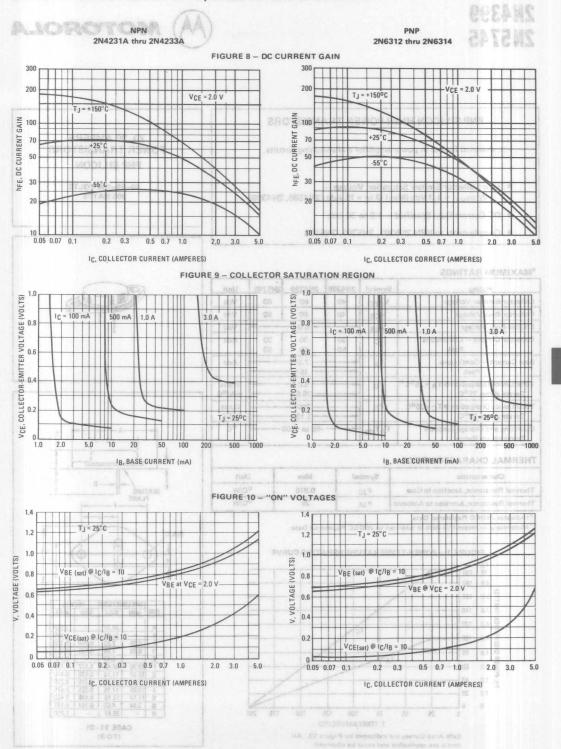




OT MUST BE FAST REDOVERY TYPE, 89

3-66

### 2N4231A thru 2N4233A NPN, 2N6312 thru 2N6314 PNP





#### PNP SILICON HIGH-POWER TRANSISTORS

. . . designed for use in power amplifier and switching circuits .

- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 1.0 Vdc (Max) @ IC = 15 Adc (2N4398, 2N4399)
- DC Current Gain Specified 1.0 to 30 Adc
- Complements to NPN 2N5301, 2N5302, 2N5303

#### 20, 30 AMPERE POWER TRANSISTORS PNP SILICON

40-60-180 VOLTS 200 WATTS

#### \*MAXIMUM RATINGS

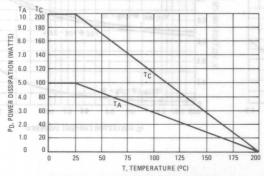
Rating	Symbol	2N4398	2N4399	2N5745	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	THE RESERVE ALL	<del>-</del> 5.0 -	-	Vdc
Collector Current — Continuous Peak	lc	30 50	30 50	20 50	Adc
Base Current — Continuous Peak	IB	7.5			Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C** Derate above 25°C	PD	5.0			Watts mW/OC
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	200			Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200			°C

#### THERMAL CHARACTERISTICS

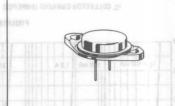
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.875	°C/W
Thermal Resistance, Junction to Ambient	θΔΑ	35	°C/W

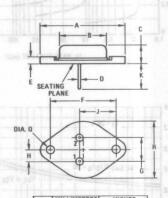
<sup>\*</sup>Indicates JEDEC Registered Data

#### FIGURE 1 - POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 13. All limits are applicable and must be observed.





	MILLIMETERS		MILLIMETERS   INCH		HES
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
B	-	21.08	0 -	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	-	3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
H	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	-	26.67	-	1.050	

CASE 11-0

<sup>\*\*</sup>Motorola guarantees this data in addition to JEDEC Registered Data.

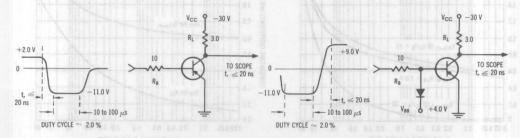
### 2N4398, 2N4399, 2N5745

	Characteristic		Symbol	Min	Max	Unit
OFF CHARACT	EBISTICS					
	er Sustaining Voltage(1)		I v			Vdc
ilc = 200 mA		2N4398	VCEO(sus)	40		Vac
110 200 1111	oc, 18 - 07	2N4399		60	1	
		2N5745		80	-	
Collector Cutof	f Current		ICEO			mAd
(VCE = 40 V	dc, I <sub>B</sub> = 0)	2N4398	000	-	5.0	
(VCE = 60 V	dc, I <sub>B</sub> = 0)	2N4399		-	5.0	
(VCE = 80 V	dc, (g = 0)	2N5745		-	5.0	
Collector Cutof			logu	A Physical Policy	1	mAc
	dc, VBE(off) = 1.5 Vdc)	2N4398	ICEX	_	5.0	mac
	dc, VBE(off) = 1.5 Vdc)	2N4399	12 5 4		5.0	
			A second		5.0	
		2N5745	- a sunni	-	10	
	dc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N4398, 2N4399		-	1.5	
	dc, VBE (off) = 1.5 Vdc, TC = 150°C)	2N5745			10	
Collector Cutof			СВО			mAd
(VCB = 40 V		2N4398	201	-	1.0	
(VCB = 60 V		2N4399		-	1.0	-
(VCB = 80 V	dc, l <sub>E</sub> = 0)	2N5745	-	-	1.0	
Emitter Cutoff	Current		IEBO	-	5.0	mAd
(VEB = 5.0 V						
ON CHARACTE	RISTICS					
DC Current Gai			hee	The second		I -
	VCE = 2.0 Vdc)	All Types	"FE	40		
	VCE = 2.0 Vdc)	2N5745		15	60	-
	V <sub>CE</sub> = 2.0 Vdc)	2N4398, 2N4399		15	60	
		2N5745		10000	00	1.11
	V <sub>CE</sub> = 2.0 Vdc)	2.107.10		5.0		
	V <sub>CE</sub> = 4.0 Vdc)	2N4398, 2N4399		5.0		
	er Saturation Voltage(1)		VCE(sat)			Vdc
(IC = 10 Adc.	I <sub>B</sub> = 1.0 Adc)	2N4398, 2N4399			0.75	
		2N5745			1.0	
(IC = 15 Adc	I <sub>B</sub> = 1.5 Adc)	2N4398, 2N4399 2N5745		-	1.0	
	I <sub>B</sub> = 2.0 Adc)	2N4398, 2N4399	2.0	10-	2.0	10
	I <sub>B</sub> = 4.0 Adc)	2N5745			2.0	
	I <sub>B</sub> = 6.0 Adc)	2N4398, 2N4399		-	4.0	
	turation Voltage(1)		VBE (sat)	BRUSP		Vdc
(IC = 10 Adc,	IB = 1.0 Adc)**	2N4398, 2N4399 2N5745		-	1.6	
11 15 Ad-	1 - 15 4 40		1	7111		-
11C - 15 Adc.	I <sub>B</sub> = 1.5 Adc)	2N4398, 2N4399 2N5745		CH	1.85	
(Io = 20 Ada	Ig = 2.0 Adc)**	2N4398, 2N4399	1		2.5	
	1g = 4.0 Adc)	2N4398, 2N4399 2N5745			2.5	
		2145745			2.5	-
Base-Emitter On		1	VBE(on)	A0.0		Vdc
	V <sub>CE</sub> = 2.0 Vdc)	2N5745		11	1.5	-
	V <sub>CE</sub> = 2.0 Vdc)	2N4398, 2N4399			1.7	
(I <sub>C</sub> = 15 Adc,					2.5	
(I <sub>C</sub> = 15 Adc,	V <sub>CE</sub> = 4.0 Vdc)	2N5745	1			
(I <sub>C</sub> = 15 Adc,		2N5745 2N4398, 2N4399			3.0	
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc,	V <sub>CE</sub> = 4.0 Vdc)				3.0	
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc,	V <sub>CE</sub> = 4.0 Vdc) V <sub>CE</sub> = 4.0 Vdc)		fr		3.0	MH
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, OYNAMIC CHA Current-Gain-E	VCE = 4.0 Vdc) VCE = 4.0 Vdc) RACTERISTICS	2N4398, 2N4399 2N4398, 2N4399	fT	4.0	3.0	MHz
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, OYNAMIC CHA Current-Gain-E (I <sub>C</sub> = 1.0 Adc	VCE = 4.0 Vdc) VCE = 4.0 Vdc) RACTERISTICS landwidth Product(2) . VCE = 10 Vdc, f = 1.0 MHz)	2N4398, 2N4399	f <sub>T</sub>	4.0	3.0	MHz
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, DYNAMIC CHA Current-Gain-E (I <sub>C</sub> = 1.0 Adc Small-Signal Cu	VCE = 4.0 Vdc) VCE = 4.0 Vdc) RACTERISTICS landwidth Product(2) VCE = 10 Vdc, f = 1.0 MHz) rrent Gain	2N4398, 2N4399 2N4398, 2N4399	f <sub>T</sub>		3.0	MH
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, DYNAMIC CHA Current-Gain-E (I <sub>C</sub> = 1.0 Adc	VCE = 4.0 Vdc) VCE = 4.0 Vdc) RACTERISTICS landwidth Product(2) . VCE = 10 Vdc, f = 1.0 MHz)	2N4398, 2N4399 2N4398, 2N4399		2.0	3.0	MH2
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, DYNAMIC CHA Current-Gain-E (I <sub>C</sub> = 1.0 Adc Small-Signal Cu (I <sub>C</sub> = 1.0 Adc	VCE = 4.0 Vdc) VCE = 4.0 Vdc) RACTERISTICS landwidth Product(2) VCE = 10 Vdc, f = 1.0 MHz) rrent Gain	2N4398, 2N4399 2N4398, 2N4399		2.0	3.0	MH
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, DYNAMIC CHA Current-Gain-E (I <sub>C</sub> = 1.0 Adc Small-Signal Cu (I <sub>C</sub> = 1.0 Adc	VCE = 4.0 Vdc) VCE = 4.0 Vdc) ARCTERISTICS landwidth Product(2) VCE = 10 Vdc, f = 1.0 MHz) rrent Gain VCE = 10 Vdc, f = 1.0 kHz)	2N4398, 2N4399 2N4398, 2N4399 2N5745 2N4398, 2N4399		2.0		MH2 -
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, OYNAMIC CHA (I <sub>C</sub> = 1.0 Adc, (I <sub>C</sub> = 1.0 Adc,	VCE = 4.0 Vdc) VCE = 4.0 Vdc) ARCTERISTICS landwidth Product(2) VCE = 10 Vdc, f = 1.0 MHz) rrent Gain VCE = 10 Vdc, f = 1.0 kHz)	2N4398, 2N4399 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745	hfe	2.0	-	-
(IC = 15 Adc, (IC = 20 Adc, (IC = 30 Adc, OYNAMIC CHA Current-Gain -E (IC = 1.0 Adc, (IC = 1.0 Adc,	VCE = 4.0 Vdc)  VCE = 4.0 Vdc   RACTERISTICS  landwidth Product(2)  VCE = 10 Vdc, f = 1.0 MHz)  Trent Gain  VCE = 10 Vdc, f = 1.0 kHz   ARACTERISTICS (See Figures 2 and 3)  (VCC = 30 Vdc, f = 1.0 Adc, f = 1.0 Adc, f = 1.0 Adc,	2N4398, 2N4399 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	hfe	2.0		MHz
(I <sub>C</sub> = 15 Adc, (I <sub>C</sub> = 20 Adc, (I <sub>C</sub> = 30 Adc, OYNAMIC CHA (I <sub>C</sub> = 1.0 Adc, (I <sub>C</sub> = 1.0 Adc,	VCE = 4.0 Vdc)  VCE = 4.0 Vdc)  RACTERISTICS  landwidth Product(2)  VCE = 10 Vdc, f = 1.0 MHz)  VCE = 10 Vdc, f = 1.0 kHz  ARACTERISTICS (See Figures 2 and 3)  (VCC = 30 Vdc, f = 30 Vdc, f = 4.0 Adc, f = 4.0 Adc,	2N4398, 2N4399 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745	hfe t <sub>r</sub>	2.0	- - - - 1.0	μs

<sup>\*</sup>Indicates JEDEC Registered Data.

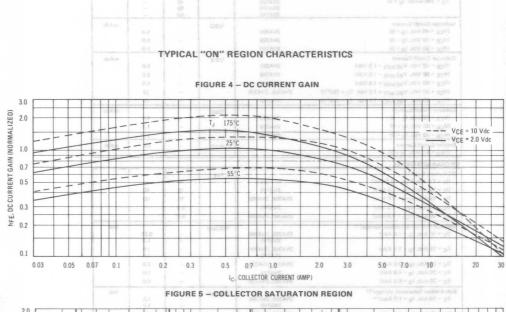
#### SWITCHING TIME EQUIVALENT TEST CIRCUITS

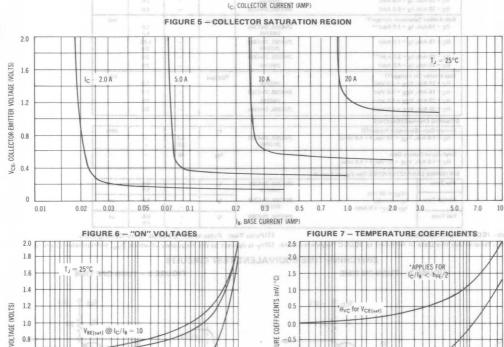


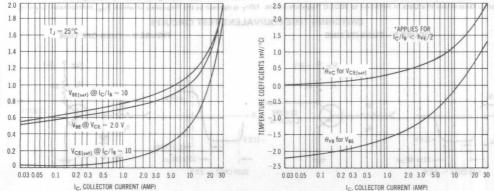


<sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

<sup>\*\*</sup>Motorola Guarantees this Data in Addition to JEDEC Registered Data. (2) fT is defined as the frequency at which |hfe| extrapolates to unity.

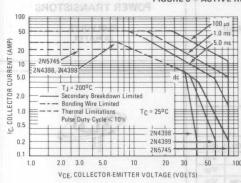






## RATINGS AND THERMAL DATA DILIZ SHE REWOR MUICE

#### FIGURE 8 - ACTIVE REGION SAFE OPERATING AREA

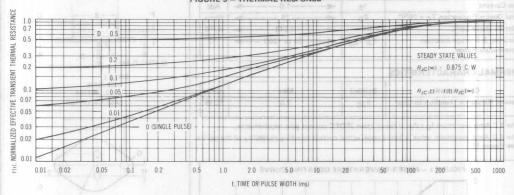


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I  $_{\rm C}-{\rm V}_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

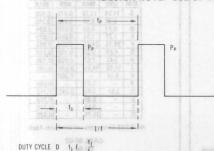
Low Saturation Voltage - VCE(sat) = 0.6 V max @ IC = 1.6

The data of Figure 8 is based on T<sub>J(pk)</sub> = 200°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \! \leq \! 200^{\text{O}}\text{C}. \ T_{J(pk)}$  may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### FIGURE 9 - THERMAL RESPONSE



#### DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



PEAK PULSE POWER PP

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal reponse, the normalized effective transient thermal resistance of Figure 9 was calculated for various duty cycles.

To find  $\theta_{J}q(t)$ , multiply the value obtained from Figure 9 by the steady state value  $\theta_{JC}(\infty)$ .

Example:

The 2N4398 is dissipating 100 watts under the following conditions:  $t_1 = 1.0 \text{ ms}$ ,  $t_P = 5.0 \text{ ms}$ . (D = 0.2)

Using Figure 9, at a pulse width of 1.0 ms and D = 0.2, the reading of r (t) is 0.28.

The peak rise in junction temperature is therefore

 $T = r(t) \times P_P \times \theta_{JC}(\infty) = 0.28 \times 100 \times 0.875 = 24.5^{\circ}C$ 

... designed for driver circuits, switching, and amplifier applications. These high-performance devices feature:

- Low Saturation Voltage VCE(sat) = 0.6 V max @ IC = 1.0 Amp
- Excellent Safe Operating Area
- Gain Specified to IC = 1.0 Ampere
- 2N4900 Complementary to NPN 2N4912

#### MAXIMUM RATINGS

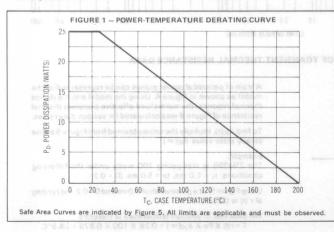
Rating	Symbol	2N4898	2N4899	2N4900	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	4	<u> 5.0</u>	-	Vdc
Collector Current — Continuous*	IC*	4	1.0 4.0	<b>&gt;</b>	Adc
Base Current	IB	4	<del></del> 1.0	-	Adc
Total Device Dissipation T <sub>C</sub> = 25°C  Derate above 25°C	PD	4	— 25 — — 0.143 –	<b>&gt;</b>	Watts W/OC
Operating & Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	1	-65 to +20	0 ->	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Reistance, Junction to Case	θЈС	7.0	°C/W

\*The 1.0 Amp maximum IC value is based upon JEDEC current gain requirements.

The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

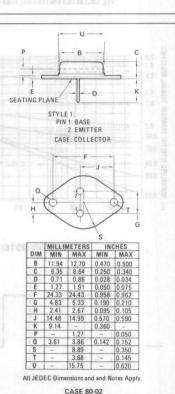


4 AMPERE

GENERAL PURPOSE POWER TRANSISTORS

> 40-80 VOLTS 25 WATTS





TO-66

#### 2N4898 thru 2N4900

#### ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit		
DFF CHARACTERISTICS								
Collector-Emitter Sustaining Voltage ( $I_C = 0.1 \text{ Adc}, I_B = 0$ )	2N4898 2N4899 2N4900		BV <sub>CEO(sus)</sub> *	40 60 80		Vdc		
Collector Cutoff Current ( $V_{CE} = 20 \text{ Vdc}, I_B = 0$ ) ( $V_{CE} = 30 \text{ Vdc}, I_B = 0$ ) ( $V_{CE} = 40 \text{ Vdc}, I_B = 0$ )	2N4898 2N4899 2N4900		I <sub>CEO</sub>	10 0 10 0	0.5 0.5 0.5	mAdo		
Collector Cutoff Current $(V_{CE} = Rated\ V_{CEO},\ V_{BE(off)} = 1$ $(V_{CE} = Rated\ V_{CEO},\ V_{BE(off)} = 1$		- 0 - 1 - 10 H	I <sub>CEX</sub>	SURSUL PINS	0.1	mAdo		
Collector Cutoff Current (V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)	Dr or o	00 00	СВО		0.1	mAdo		
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		Cano BMSC J	I <sub>EBO</sub>	-	1.0	mAde		

#### ON CHARACTERISTICS

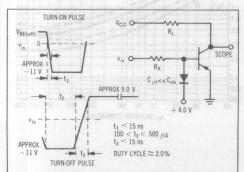
DC Current Gain* (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc)	FE*	40	BR-BVITOA — 0	18 . 3)1-
$(I_C = 500 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc})$		20	100	
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	HALL	10		0.0
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub> *		0.6	Vdc
Base-Emitter Saturation Voltage* (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>BE(sat)</sub> *		1.3	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 1.0 Adc, V <sub>C</sub> E = 1.0 Vdc)	V <sub>BE(on)</sub> *	TIMU - SI NO	1.3	Vdc

#### SMALL SIGNAL CHARACTERISTICS

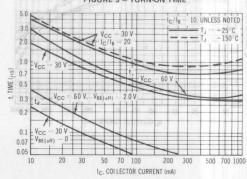
Current-Gain—Bandwidth Product $(I_C - 250 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ MHz})$	f <sub>T</sub> cue	3.0	VOT CONTRE	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	C <sub>ob</sub>	-	100	pF
Small-Signal Current Gain $(I_C = 250 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz})$	h <sub>fe</sub>	7 30 25 013 -	e sauers	-

\* Pulse Test: PW ≈300 μs, Duty Cycle ≈ 2.0%

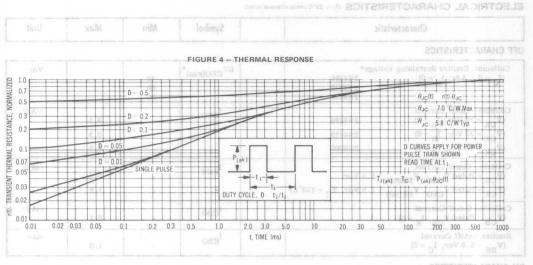
#### FIGURE 2 - SWITCHING TIME EQUIVALENT CIRCUIT

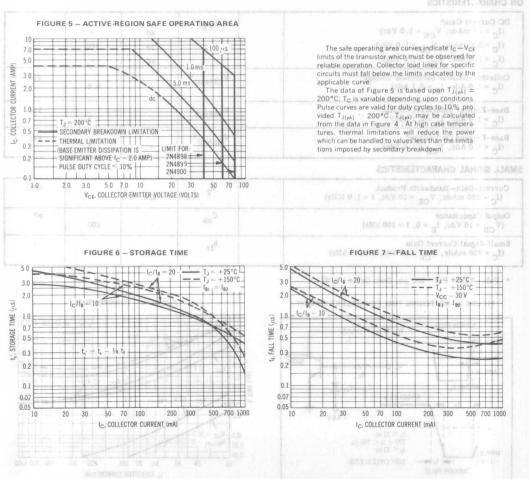


#### FIGURE 3 - TURN-ON TIME











#### NPN SILICON TRANSISTOR

... designed for driver circuits, switching, and amplifier applications. This high-performance device features:

- Low Saturation Voltage VCE(sat) = 0.6 V max @ IC = 1.0 Amp
- Excellent Safe Operating Area
- Gain Specified to IC = 1.0 Amp
- Complement to PNP 2N4900

## ELECTRICAL CHARACTERISTICS OF

## NPN SILICON POWER TRANSISTOR

80 VOLTS



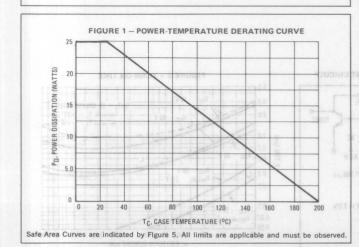
#### MAXIMUM RATINGS

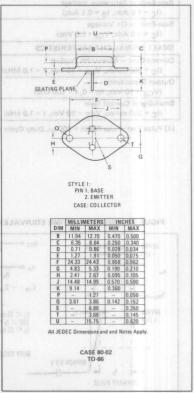
	Rating	Ob.	Symbol	Value	Unit
Collector-Emitte	er Voltage	20	VCEO	80	Vdc
Collector-Base \	/oltage	10	VCB	80	Vdc
Emitter-Base Vo	oltage 8.0	- 7	VEB	5.0	Vdc
Collector Curren	nt - Continuous*		Ic*	1.0	Adc
30V	1.3	-	(76)	8V	
Base Current -	Continuous		IB	1.0	Adc
Total Device Dis Derate above	ssipation T <sub>C</sub> = 25°C e 25°C		P <sub>D</sub> (no)	25 0.143	Watts mW/ <sup>O</sup> C
Operating & Sto		n.e.	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	7.0	°C/W

<sup>\*</sup>The 1.0 Amp maximum I<sub>C</sub> value is based upon JEDEC current gain requirements.





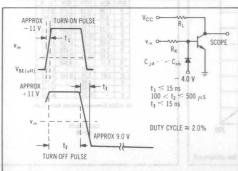


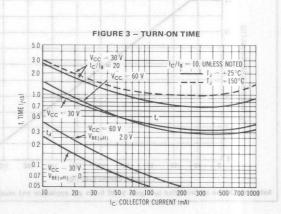
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (IC = 0.1 Adc, IB = 0)	.znotysofiqu	BV <sub>CEO(sus)</sub>	80	a for driver one unformance des	Vdc
Collector Cutoff Current (VCE = 40 Vdc, IB = 0)	qmA 0.1 =	ICEO 00 =	1 - VOE(sat)	0.5	mAdc
Collector Cutoff Current (VCE = Rated VCEO, VEB(off) = 1.5 Vdc) (VCE = Rated VCEO, VEB(off) = 1.5 Vdc, TC	= 150°C)	ICEX	0.0 Ange (4900–	0.1	
Collector Cutoff Current (V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)		ICBO	-	0.1	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO	-	1.0	mAdc
ON CHARACTERISTICS (1)			ALEX III	2010	rag. Hw
DC Current Gain (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	rint) t	% OSON	40 20 10	100	V sersion 3-10
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	Vde Ado	VCE(sat)	-	0.6	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	Ado	V <sub>BE</sub> (sat)		1.3	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> - 1.0 Vdc)	Vents 1	VBE(on)	-	5 23 1.37 notes	Vdc
SMALL SIGNAL CHARACTERISTICS	200 000	L. Teta - 65 to +	T	notional t	ng A. Storag
Current-Gain — Bandwidth Product (IC = 250 mAdc, VCE = 10 Vdc, f = 1.0 MHz)		fT	3.0	ngs RACTERISTIC	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	Unit 90 W	C <sub>ob</sub>	-	100 tams.	-

(I<sub>C</sub> = 250 mAdc, V<sub>CE</sub> = 10 Vdc, f = 1.0 kHz)
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

Small-Signal Current Gain





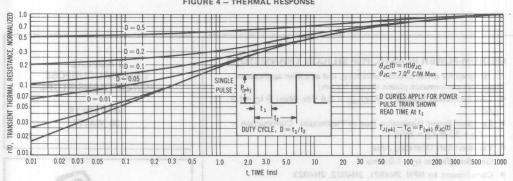


25

hfe

0.1 1.0

ALOROTOM



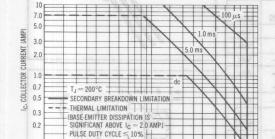


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub> – V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

pation than the curves indicate. The dafa of Figure 5 is based on  $T_{J\{pk\}}=200\,^{\circ}\text{C}$ :  $T_{\text{C}}$  is variable depending on conditions. Pulse curves are valid for duty cycles of  $10\,^{\circ}\text{K}$  provided  $T_{J\{pk\}} \leq 200\,^{\circ}\text{C}$ .  $J_{J\{pk\}}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



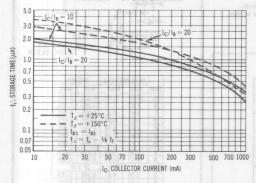
VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

5.0 7.0 10

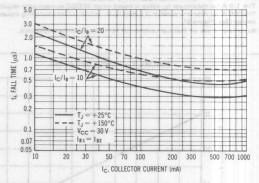
20

70 100

3.0



#### FIGURE 7 - FALL TIME





#### MEDIUM-POWER PLASTIC PNP SILICON TRANSISTORS

... designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage VCE(sat) = 0.6 Vdc (Max) @ IC = 1.0
- Excellent Power Dissipation Due to Thermopad Construction PD = 30 @ TC = 25°C
- Excellent Safe Operating Area
- Gain Specified to I<sub>C</sub> = 1.0 Amp
- Complement to NPN 2N4921, 2N4922, 2N4923

#### \*MAXIMUM RATINGS

Ratings and with no an	Symbol	2N4918	2N4919	2N4920	Unit	
Collector-Emitter Voltage	VCEO	40	60	80	Vdc	
Collector-Base Voltage	VCB	40	60	80	Vdc	
Emitter-Base Voltage and angle of the long	VEB	12-	5.0	-	Vdc	
Collector Current - Continuous (1)	Ic*	o greb and	1.0	-	Adc	
ending on conditions.	priefile de	TOT TOLES	3.0 —	-	H	
Base Current	T IBOOS	The service of	1.0	-	Adc	
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	t me cau n s, thermal can be lo	30 0.24		Watts W/ <sup>O</sup> C	
Operating & Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	KING BIOTS	-65 to +15	50 —	°C	

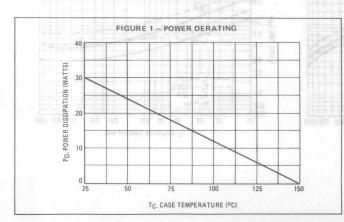
#### THERMAL CHARACTERISTICS (2)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	4.16	°C/W

\*Indicates JEDEC Registered Data for 2N4918 Series

- (1) The 1.0 Amp maximum I<sub>C</sub> value is based upon JEDEC current gain requirements.

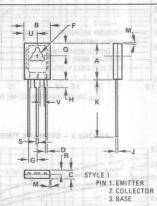
  The 3.0 Amp maximum value is based upon actual current-handling capability of the device (See Figure 5).
- (2) Recommend use of thermal compound for lowest thermal resistance.



3 AMPERE GENERAL-PURPOSE POWER TRANSISTORS

> 40-80 VOLTS 30 WATTS





	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
H	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	0 TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-

TO-126

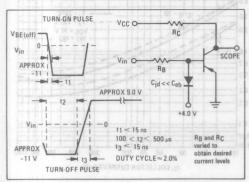
ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

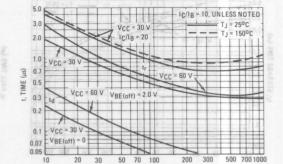
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0) 2N4918	PRIBA JAMAS BITT FEET	VCEO(sus)	40		Vdc
2N4919 2N4920			60 80	T I	5.0
Collector Cutoff Current		ICEO	0.2		mAdc
(V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) 2N4918				0.5	
(V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) 2N4919				0.5	
(V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) 2N4920	protection			0.5	
Collector Cutoff Current		ICEX			mAdc
(V <sub>CE</sub> = Rated V <sub>CEO</sub> , V <sub>BE(off)</sub> = 1.5 Vdc)			-	0.1	
(V <sub>CE</sub> = Rated V <sub>CEO</sub> , V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 125°C)	11 - 190 - 100			0.5	B1-4-190
Collector Cutoff Current		Ісво	38	DA BTONIS	mAdc
(V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)	grate n. 9,12Ya	crea III		0.1	
Emitter Cutoff Current (VRE = 5.0 Vdc, IC = 0)		IEBO		1.0	mAdc
ON CHARACTERISTICS	0.6 0.0 1	X 11 8	0 100 500	0 80.0 10.0	50.0 10.0
	(Zm) 3MF (ms)				
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)		hFE	40 30	_ 150	
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)		ATING AREA	STO STID MOIS	S - ACTIVER	BHUSH
Collector-Emitter Saturation Voltage (1)		VCE(sat)	and the second of the second o		Vdc .
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)		HIJX		0.6	
Base-Emitter Saturation Voltage (1)	sit 6	V <sub>BE(sat)</sub>	1 × 1 × 1		Vdc
(IC = 1.0 Adc, IB = 0.1 Adc) www as a profession state	wab	DE(Sat)	20002 A	1.3	
Base-Emitter On Voltage (1)		V <sub>BE</sub> (on)		20001-1	Vdc
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	rianti	BE(011)	12-	1.3	,,,,
SMALL-SIGNAL CHARACTERISTICS	Tol	HAVE	KW008A	RB GWGC 32	
Current-Gain - Bandwidth Product blisv eng at mil	eatuct	tr /	THE LIMITED IN	w амідиов — —	MHz
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	o)LT		3.0	HEALTH	21
Output Capacitance	nerts	Cob		TUTSE KIPER SSVII	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)			- 1	100	BI di Ta
Small-Signal Current Gain		h <sub>fe</sub>			1 10
(IC = 250 mAdc, VCF = 10 Vdc, f = 1.0 kHz)	THE PROPERTY OF	001 00 100	25	21 53 00	

<sup>\*</sup>Indicates JEDEC Registered Data

<sup>(1)</sup> Pulse Test: PW ≈ 300 µs, Duty Cycle ≈ 2.0%







IC, COLLECTOR CURRENT (mA)

FIGURE 3 - TURN-ON TIME

3-79



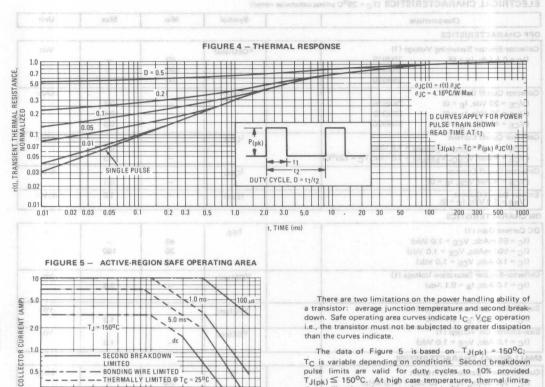
2.0

0.5

0.2

0.1

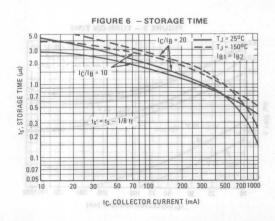
10,0



50 70 100

down. Safe operating area curves indicate IC - VCE operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on TJ(pk) = 150°C;

T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



SECOND BREAKDOWN

- RONDING WIRE LIMITED

5.0 7.0 10

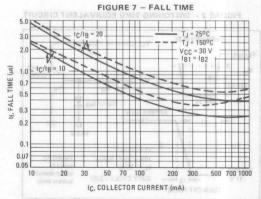
PULSE CURVES APPLY BELOW

3.0

RATED VCEO

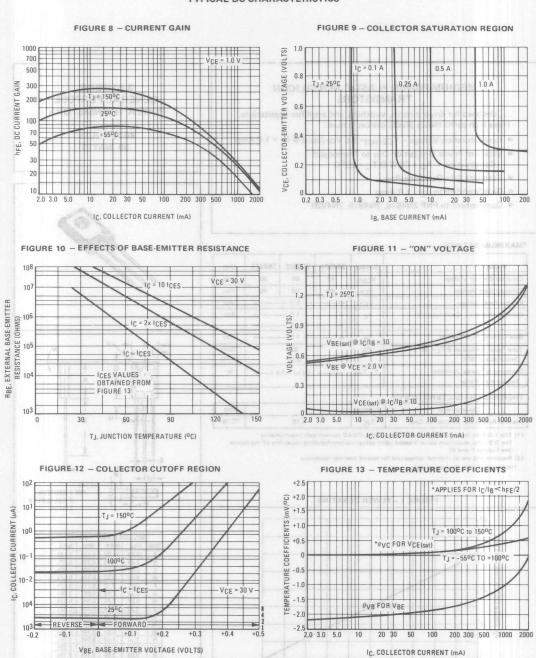
- THERMALLY LIMITED @ TC = 25°C

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)



ALOROTOM

#### TYPICAL DC CHARACTERISTICS





PIGURE 9 - COLLECTOR SATURATION REGION

#### MEDIUM-POWER PLASTIC NPN SILICON **TRANSISTORS**

. . designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage −VCE(sat) = 0.6 Vdc (Max) @ IC = 1.0 Amp
- Excellent Power Dissipation Due to Thermopad Construction - PD = 30 W @ TC = 25°C
- Excellent Safe Operating Area
- Gain Specified to IC = 1.0 Amp
- Complement to PNP 2N4918, 2N4919, 2N4920

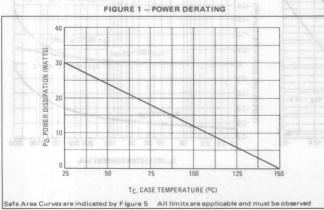
#### \*MAXIMUM RATINGS

20070000 120000 10000	C. P. PRESPONDED.				CONTRACT OF
Rating	Symbol	2N4921	2N4922	2N4923	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	5.0 -	-	Vdc
Collector Current - Continuous (1)	l'C :	-	1.0 -	-	Adc
		-	3.0 -	-	
Base Current - Continuous	18	-	1.0 -	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD		30	P	Watt
Derate above 25°C		学生	0.24		W/OC
Operating & Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	A 198 A	-65 to +15	50	°С
Temperature Range			Lin		

### THERMAL CHARACTERISTICS (2)

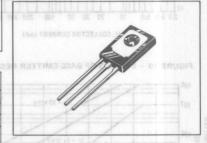
Characteristic	Symbol		Unit
Thermal Resistance, Junction to Case	θ θJC	4.16	°C/W

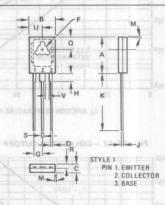
- (1) The 1.0 Amp maximum  $I_C$  value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figures 5 and 6).
- (2) Recommend use of thermal compound for lowest thermal resistance \*Indicates JEDEC Registered Data:



#### 3 AMPERE GENERAL-PURPOSE **POWER TRANSISTORS**

**40-80 VOLTS** 30 WATTS





	MILLIM	MILLIMETERS INC			
MIC	MIN	MAX	MIN	MAX	
A	10.80	11.05	0.425	0.435	
В	7.49	7.75	0.295	0.305	
C	2.41	2.67	0.095	0.105	
D	0.51	0.66	0.020	0.026	
F	2.92	3.18	0.115	0.125	
G	2.31	2.46	0.091	0.097	
Н	1.27	2.41	0.050	0.095	
J	0.38	0.64	0.015	0.025	
K	15.11	16.64	0.595	0.655	
M	3	O TYP	30 T	YP	
0	3.76	4.01	0.148	0.158	
R	1.14	1.40	0.045	0.055	
S	0.64	0.89	0.025	0.035	
U	3.68	3.94	0.145	0.155	
٧	1.02	-	0.040	-	

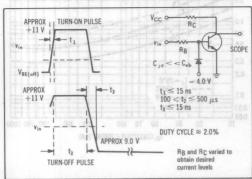
TO-126

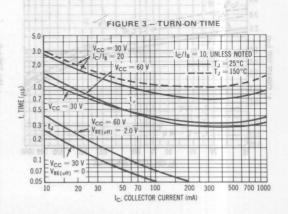
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					0.5
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0) 2N4921 2N4922		VCEO(sus)	40 60	1 <u>1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 </u>	Vdc
2N4923  Collector Cutoff Current (VCE = 20 Vdc, I <sub>B</sub> = 0) (VCE = 30 Vdc, I <sub>B</sub> = 0) 2N4921 (VCE = 40 Vdc, I <sub>B</sub> = 0) 2N4922 (VCE = 40 Vdc, I <sub>B</sub> = 0) 2N4923		ICEO	80	0.5 0.5 0.5	mAdc
Collector Cutoff Current (VCE = Rated VCEO, VEB(off) = 1.5 Vdc) (VCE = Rated VCEO, VEB(off) = 1.5 Vdc, TC = 125°C)	פאור כיוטוב. ם	ICEX		0.1 0.5	mAdc
Collector Cutoff Current (V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)		СВО	_	0.1	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO	_	1.0	mAdo
ON CHARACTERISTICS	ABRA DWO	SAFE OPERAT	NOIDER -	b - ACTIVE	FIGURE
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	W (80)	hFE	40 30 10	150	7.0
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)		VCE (sat)		0.6	Vdc
Base-Emitter Saturation Voltage (1) http://doi.org/10.100/10.0007/10.0	WA	V <sub>BE</sub> (sat)	OND BREAKB	1.3	Vdc
Base-Emitter On Voltage (1) (I $_{\rm C}$ = 1.0 Adc, V $_{\rm CE}$ = 1.0 Vdc)	MA	V <sub>BE</sub> (on)	MILLYJUMER	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS	HAA			T DEOV DETAIL	0.2
Current-Gain — Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	80 20 10	f <sub>T</sub>	3.0 03	00-03	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	. ret	C <sub>ob</sub>	CTOR_EMITTE	100	pF
Small-Signal Current Gain (I <sub>C</sub> = 250 mAdc, V <sub>CF</sub> = 10 Vdc, f = 1.0 kHz)		h <sub>fe</sub>	25		-

<sup>(1)</sup> Pulse Test: PW≈ 300 µs, Duty Cycle ≈ 2.0%.

#### FIGURE 2 - SWITCHING TIME EQUIVALENT CIRCUIT





<sup>\*</sup>Indicates JEDEC Registered Data



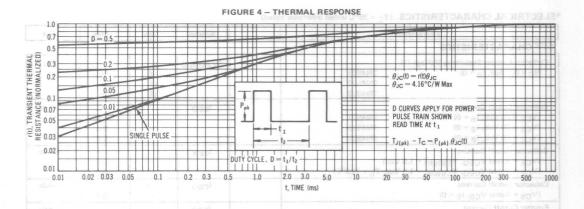
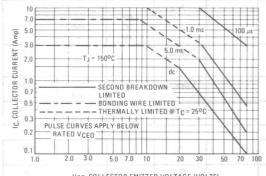


FIGURE 5 - ACTIVE - REGION SAFE OPERATING AREA

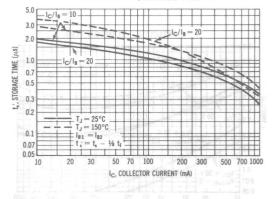


VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

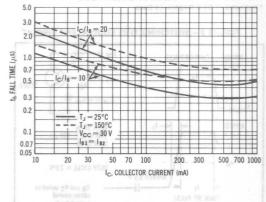
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\text{C}} \cdot V_{\text{CE}}$  operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 150^{\circ}C$ ; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

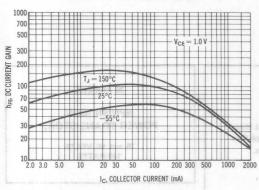




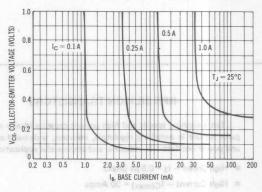
#### FIGURE 7 - FALL TIME



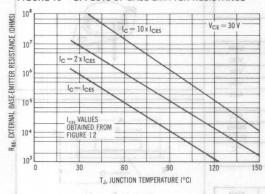




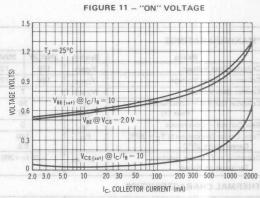
#### FIGURE 9 - COLLECTOR SATURATION REGION



#### FIGURE 10 - EFFECTS OF BASE-EMITTER RESISTANCE



Low Saturation - VicE(set) = 2.6 V (Max) @ Lo = 20 Amps



#### FIGURE 12 - COLLECTOR CUTOFF REGION

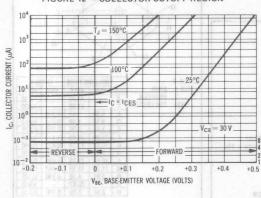
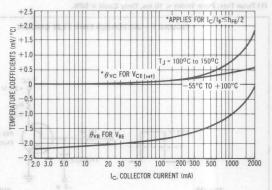


FIGURE 13 - TEMPERATURE COEFFICIENTS





#### NPN SILICON TRANSISTORS

. . . fast switching speeds and high current capacity ideally suit these parts for use in switching regulators, inverters, wide-band amplifiers and power oscillators in industrial and commercial applications.

- High Speed  $t_f = 0.5 \,\mu s$  (Max)
- High Current IC(max) = 30 Amps

FIGURE 9 - COLLECTOR SATURATION ROTH

Low Saturation - V<sub>CE(sat)</sub> = 2.5 V (Max) @ I<sub>C</sub> = 20 Amps

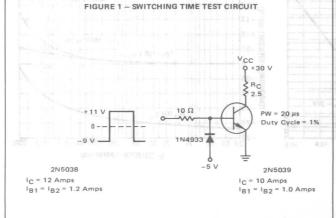
#### \*MAXIMUM RATINGS

Rating	Symbol	2N5038	2N5039	Unit
Collector-Base Voltage	VCBO	150	120	Vdc
Collector-Emitter Voltage	V <sub>CEV</sub> 150		120	Vdc
Emitter-Base Voltage	VEBO	7		Vdc
Collector Current — Continuous Peak (1)	I <sub>C</sub>	20 30		Adc
Base Current — Continuous	IB	5		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	140 0.8		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.25	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data.



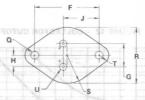
#### 20 AMPERE

#### NPN SILICON **POWER TRANSISTORS**

75 and 90 VOLTS 140 WATTS







TYLE 1		-	MILLIN	METERS	INCHES		
PIN 1.	BASE	DIM	MIN	MAX	MIN	MAX	
2.	EMITTER	A		39.37	- 1	1,550	
CASE	COLLECTOR	В		21.08		0.830	
		C	6.35	7.62	0.250	0.300	
		D	0.97	1.09	0.038	0.043	
	N	E	1.40	1.78	0.055	0.070	
		F	29.90	30.40	1.177	1.197	
		G	16.67	11.18	0.420	0.440	
		Н	5.33	5.59	0.210	0.220	
		J	16.64	17.15	0.655	0.675	
	S.0 F	K	11.18	12.19	0.440	0.480	
		.0	3.81	4.19	0.150	0.165	
		R	wo Till a	26.67	-	1.050	
		U	2.54	3.05	0.100	0.120	

CASE 1-04

ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

<sup>(1)</sup> Pulse Test: Pulse Width ≤ 10 ms, Duty Cycle ≤ 50%.



#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted).

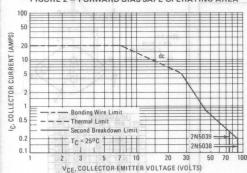
Characteristic				Symbol	M	n	Max	2.00	Unit	
OFF CHARACTERISTICS										8 H3 H
Collector-Emitter Sustaining (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0			2N5038 -2N5039	SISM	VCEO(sus)	91		HUM-PON	SED	Vdc
Collector Cutoff Current (VCE = 140 Vdc, VBE(c) (VCE = 110 Vdc, VBE(c) (VCE = 100 Vdc, VBE(c) (VCE = 85 Vdc, VBE(c)	off) = 1.5 V) off) = 1.5 Vdc, T <sub>C</sub> = 15		2N5038 2N5039 2N5038 2N5039	e gnirk		qma b	- 25	50	desig	mAdc
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0) (VEB = 7 Vdc, IC = 0)	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		2N5038 2N5039 Both		IC = 0.78 Wed	1051014	d ret	5.00		mAdc
ON CHARACTERISTICS (1)			Both	<del>9000 01</del>	OT variability	delta.	cogn	50	900	-07 B
DC Current Gain (I <sub>C</sub> = 12 Adc, V <sub>CE</sub> = 5) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 5)	Vdc)		2N5038 2N5039		hFE	20		100 100		-
Collector-Emitter Saturatio (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 5 Ad					VCE(sat)	-		2.5	TAR	Vdc
Base-Emitter Saturation Vo		rinU	2MS092	150811	V <sub>BE</sub> (sat)	Syl			gniing V ven	Vdc
DYNAMIC CHARACTERIST	rics	oloV	200	150	125 as	V		901	Hov	Gap4-5070
Magnitude of Common-Emi Forward Current Transf (I <sub>C</sub> = 2 Adc, V <sub>CE</sub> =	er Ratio	-Circuit		2.0	lh <sub>fe</sub> !	1	2	ja – Continuous	orto - tel	ter Bute V
SWITCHING CHARACTERI	STICS	a72507		01			2085	and Groot	oaise	
RESISTIVE LOAD		OP/W		0.266						राज्यां हरें हैं
Rise Time (\	/CC = 30 Vdc)	20	8	11+ 013	tr		sont P	0.5	500	μς

2N5038

2N5039

#### Storage Time $(I_C = 12 \text{ Adc}, I_{B1} = I_{B2} = 1.2 \text{ Adc})$ Fall Time $(I_C = 10 \text{ Adc}, I_{B1} = I_{B2} = 1 \text{ Adc})$

#### FIGURE 2 - FORWARD BIAS SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

1.5

0.5

Second breakdown pulse limits are valid for duty cycles to 10%. At high case temperatures, thermal limitations may reduce the power that can be handled to values less than the limitations imposed by second breakdown.

<sup>\*</sup>Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.



\*ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise notes

#### MEDIUM-POWER NPN SILICON TRANSISTORS

designed for untuned amplifier and switching applications.

- High Voltage Ratings VCEO = 125, 150 and 200 Vdc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 0.75 Adc
- Packaged in the Compact, High Efficiency TO-66 Case

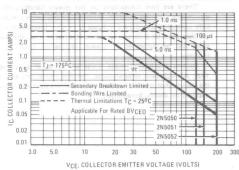
## \*MAXIMUM RATINGS

Rating	Symbol	2N5050	2N5051	2N5052	Unit
Collector-Emitter Voltage	VCEO	125	150	200	Vdc
Collector-Base Voltage	V <sub>CB</sub>	125	150	200	Vdc
Emitter-Base Voltage	VEB	erit	6.0		Vdc
Collector Current - Continuous	1c		2.0		Adc
Base Current	IB		1.0		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		40 0.266		Watts W/OC
Operating Junction Temperature Range	TJ	-65 to +175		5	оС
Storage Temperature Range	T <sub>stg</sub>	27	65 to +20	0 tobal	°C °

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	3.76	°C/W
Indicates JEDEC Registered Data.		7	JRA D

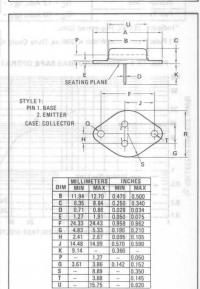
#### FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I<sub>C</sub>-V<sub>CE</sub> limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.

#### 2 AMPERE POWER TRANSISTORS NPN SILICON

125-200 VOLTS 40 WATTS



All JEDEC Dimensions and and Notes Apply

CASE 80-02 TO-66

2N5190 thru 2N5192



#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic			Min	Max	Unit						
OFF CHARACTERISTICS											
	2N5050 2N5051 2N5052	VCEO(sus)	100	_							
	2N5050 2N5051 2N5052	ICEO	- - -	0.1	mAdc						
60°C)	08 01 - 09 00 0	ICEX		0.5 5.0	mAdc						
36A 8/36/7 3/9/9/30	0	IEBO B	-	0.1	mAdc						
		2N5051 2N5052 2N5050 2N5051 2N5052	2N5050 2N5051 2N5051 2N5052 2N5050 2N5050 2N5051 2N5052 ICEO	2N5050 VCEO(sus) 125 2N5051 150 2N5052 200  1CEO - 2N5050 - 2N5051 - 2N5052 -  1CEX - 0°C) -	2N5050 2N5051 2N5052 1CEO  2N5050  - 0.1  2N5052 - 0.1  2N5052 - 0.1  1CEX - 0.5  100°C)  1EBO - 0.1						

#### \*ON CHARACTERISTICS

DC Current Gain (Note 1)		hFE		SOLTENBETO S	THERMAL CHA
(I <sub>C</sub> = 0.75 Adc, V <sub>CE</sub> = 5.0 Vdc)	1000		25	100	
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	21.0		25	and at women	
(I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	-		5.0	_	
Collector-Emitter Saturation Voltage (Note 1)		VCE (sat)			Vdc
(I <sub>C</sub> = 0.75 Adc, I <sub>B</sub> = 0.1 Adc)			-	1.0	
(I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 0.4 Adc)			-	5.0	
Base-Emitter On Voltage (Note 1)		VBE (on)	and a Pic - 5	1.2 JARA	Vdc
(I <sub>C</sub> = 0.75 Adc, V <sub>CE</sub> = 5.0 Vdc)	Ma	Symbol Min		Characterytic	

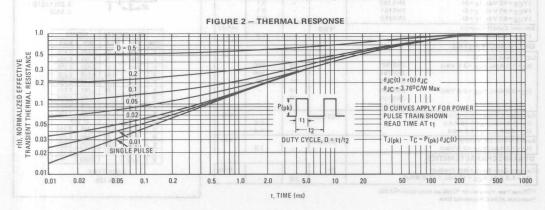
#### \*DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 5.0 MHz)			98 fT	10 erant	- 40	MHz
Small-Signal Current Gain (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	ali Am	0.1 107	h <sub>fe</sub>	25 1012HS	- 10 or 10 o	Surgin <u>a</u> torastion or risk OA + 3gV or risk V OA + 3gV
Common Base Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	shAm 3	1.0	Cob	ans sub-	250	pF

#### \*SWITCHING CHARACTERISTICS

Rise Time	(V <sub>CC</sub> = 120 Vdc, I <sub>C</sub> = 750 mAdc, R <sub>L</sub> = 150 Ohms, I <sub>B1</sub> = I <sub>B2</sub> = 100 mAdc)	t <sub>r</sub>	VETOR	300	ns
Storage Time		t <sub>s</sub>	151300	3.5	μs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 100 mAdc)	tf	- 5151,030	1.2	μs

\*Indicates JEDEC Registered Data. Note 1: Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.



#### SILICON NPN POWER TRANSISTORS

. . . for use in power amplifier and switching circuits, - excellent safe area limits. Complement to PNP 2N5193, 2N5194, 2N5195

#### \*MAXIMUM RATINGS

		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						
Rating	Symbol	2N5190	2N5191	2N5192	Unit			
Collector-Emitter Voltage	VCEO	40	60	80	Vdc			
Collector-Base Voltage	VCB	40	60	80	Vdc			
Emitter-Base Voltage	VEB	-	<u>- 5.0 -</u>	-	Vdc			
Collector Current	1 <sub>C</sub>	-	<u> 4.0 -</u>	-	Adc			
Base Current	I <sub>B</sub>	Charles	1.0	-	Adc			
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		40 320		Watts mW/ <sup>O</sup> C			
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +15	0	°C			

#### THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Case	0.7	$\theta_{ m JC}$	3.12	°CW

\*ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS		- 1 1			
Collector-Emitter Sustaining Voltage ( (IC = 0.1 Adc, I <sub>B</sub> = 0)	1) 2N5190 2N5191 2N5192	VCEO(sus)	40 60 80	-	Vdc
Collector Cutoff Current (VCE = 40 Vdc, IB = 0) (VCE = 60 Vdc, IB = 0) (VCE = 80 Vdc, IB = 0)	2N5190 2N5191 2N5192	CEO	-	1.0 1.0 1.0	mAdc
Collector Cutoff Current  (VCE = 40 Vdc, VEB(off) = 1.5 Vdc)  (VCE = 60 Vdc, VEB(off) = 1.5 Vdc)  (VCE = 80 Vdc, VEB(off) = 1.5 Vdc)	2N5190 2N5191 2N5192	CEX		0.1 0.1	mAdc

2143130		-	0.1	
2N5191		-	0.1	
2N5192		-	0.1	
2N5190	7.7	-	2.0	
2N5191	27		2.0	
2N5192	+2	-	2.0	
rdo e22.8%	1CBO	nnes	plate that made	mAdc
2N5190	1	_	0.1	
2N5191	1		0.1	
2N5192	adio/1921	His Tax	0.1	
	IEBO			mAdc
	11681	-	1.0	
	2N5191 2N5192 2N5190 2N5191 2N5192 2N5192	2N5191 2N5192 2N5190 2N5191 2N5192 2N5192 2N5190 2N5191 2N5191 2N5192	2N5191 - 2N5192 - 2N5191 - 2N5192 - 2N5191 - 2N5191 - 2N5191 - 2N5192 - 2N5	2N5191 - 0.1 2N5192 - 0.1 2N5190 - 2.0 2N5191 - 2.0 2N5192 - 0.1 2N5192 - 0.1 2N5190 - 0.1 2N5190 - 0.1 2N5190 - 0.1 2N5190 - 0.1

ON CHARACTERISTICS			
DC Current Gain(1)		hFE	
(IC = 1.5 Adc, VCE = 2.0 Vdc)	2N5190		25
	2N5191		25
	2015102	10.11	20

	2145192		20	80	and the latest of
(IC = 4.0 Adc, VCE = 2.0 Vdc)	2N5190		10	-	
	2N5191	from	10		1750
HE HE TANKS KON YOR	2N5192		7.0		122
Collector-Emitter Saturation Voltag	je(1) 12 / 19	VCE(sat)	- Just		Vdd
(IC = 1.5 Adc, IB = 0.15 Adc)			11 15	0.6	
(IC = 4.0 Adc, IB = 1.0 Adc)		7-5		1.4	- 1-1-1
Base-Emitter On Voltage (1)	ST EmiliT+	VBE(on)	YO YTUE		Vd
(Ic=15 Adc Vc==20 Vdc)				1 2	THE T

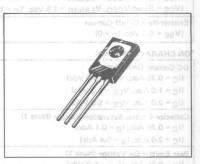
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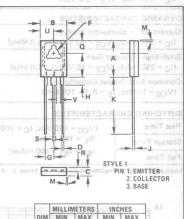
MIC CHARACTERISTICS
Gain-Bandwidth Product  O Adc, VCF = 10 Vdc, f = 1.0 MHz)

<sup>(1)</sup> Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
\*Indicates JEDEC Registered Data



40-80 VOLTS 40 WATTS Shy of = 30V)

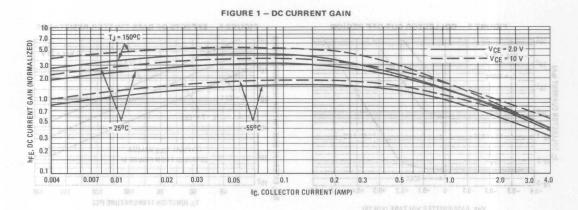


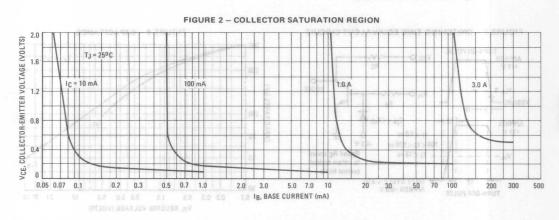


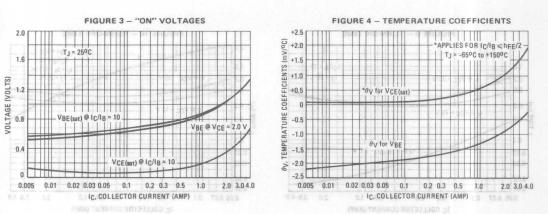
-	MILEFIN	FIEHS	IIVL	HE2	14
M	MIN	MAX	MIN	MAX	Ħ
A	10.80	11.05	0.425	0.435	Н
В	7.49	7.75	0.295	0.305	11
C	2.41	2.67	0.095	0.105	u
)	0.51	0.66	0.020	0.026	]]
F	2.92	3.18	0.115	0.125	]
G	2.31	2.46	0.091	0.097	И
H	1.27	2.41	0.050	0.095	U
J	0.38	0.64	0.015	0.025	Н
K	15.11	16.64	0.595	0.655	l
N	3	O TYP	30 T	YP	1
1	3.76	4.01	0.148	0.158	
3	1.14	1.40	0.045	0.055	
S	0.64	0.89	0.025	0.035	
U	3.68	3.94	0.145	0.155	H
٧	1.02	-	0.040	200	
	(	CASE 77	7-04		
		TO-12	6		

MHz

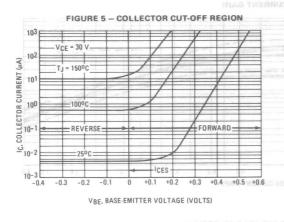


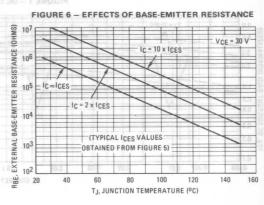


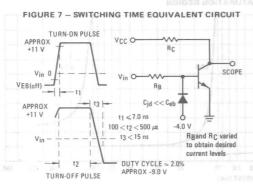


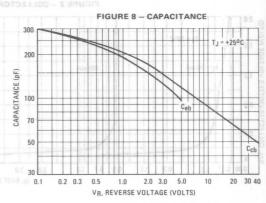


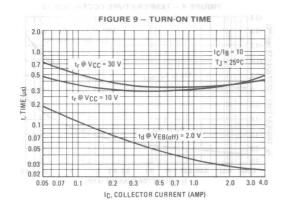












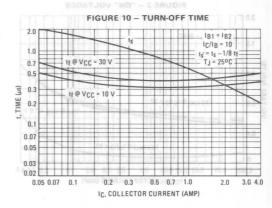
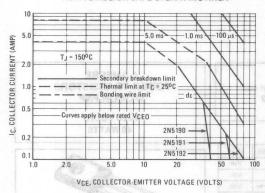


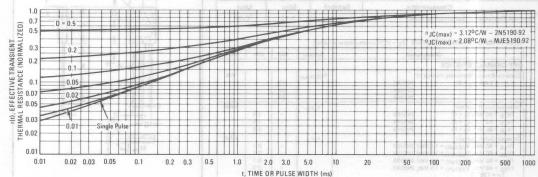
FIGURE 11 RATING AND THERMAL DATA ACTIVE-REGION SAFE OPERATING AREA



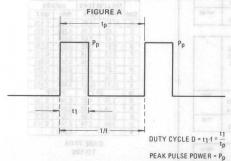
There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I $_{\rm C}$  - V $_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on  $T_{J(pk)}=150^{o}C;\ T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}\!\leq\!150^{o}C.$  At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 12 - THERMAL RESPONSE



#### DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find  $\theta_{JC}(t),$  multiply the value obtained from Figure 12 by the steady state value  $\theta_{JC}.$ 

Example:

The 2N5190 is dissipating 50 watts under the following conditions:  $t_1$  = 0.1 ms,  $t_P$  = 0.5 ms. (D = 0.2).

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of  $r(t_1, D)$  is 0.27.

The peak rise in junction temperature is therefore:

 $\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2^{\circ}C$ 

#### SILICON PNP POWER TRANSISTORS

... for use in power amplifier and switching circuits, - excellent safe area limits. Complement to NPN 2N5190, 2N5191, 2N5192

## \*MAXIMUM RATINGS believe to 100 to 10

bridges, yo La o'Ratingoristimil and nea	Symbol	2N5193	2N5194	2N5195	Unit
Collector-Emitter Voltage	VCEO	40 🕾	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	4	— 5.0 —	-	Vdc
Collector Current	1 <sub>C</sub>	4	<del></del> 4.0 <del></del>	-	Adc
Base Current	I <sub>B</sub>	4	<u> 1.0 – </u>	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	4	40 320	-	Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +15	50	°C/W

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	0,1C	3.12	°C/W

#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Cha	racteristic		Symbol	Min	Max	Unit	1
OFF CHARACTERISTICS							
Collector-Emitter Sustaining Volt (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	2N5193		VCEO(sus)	40		Vdc	
	2N5194 2N5195			60 80			
Collector Cutoff Current			ICEO			mAdc	
(V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N5193			-	1.0		
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	2N5194			-	1.0		
(VCE = 80 Vdc, IB = 0)	2N5195				1.0		-
Collector Cutoff Current	ENGLA DATE 400		CEX		0.1	mAdc	-
(VCE = 40 Vdc, VBE(off) = 1.1 (VCE = 60 Vdc, VBE(off) = 1.1					0.1		
(VCE = 80 Vdc, VBE(off) = 1.5 (VCE = 40 Vdc, VBE(off) = 1.5 TC = 125°C)	5 Vdc) 2N5195		g.a (mo.) PPT G (M	3.0	0.1	0.1	No.
(V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> (off) = 1.1 T <sub>C</sub> = 125°C)				-	2.0		
(V <sub>CE</sub> = 80 Vdc, V <sub>BE (off)</sub> = 1.9 T <sub>C</sub> = 125°C)	5 Vdc, 2N5195			-	2.0		
Collector Cutoff Current			1CBO			mAdc	
(VCB = 40 Vdc, IE = 0)	2N5193			20100	0.1		-
(VCB = 60 Vdc, IE = 0) (VCB = 80 Vdc, IE = 0)	2N5194 2N5195	IL RESISTA	KINEPI 258-5 I	1 04 3	0.1	OF TH	45
Emitter Cutoff Current (VBE = 5.0 Vdc, I <sub>C</sub> = 0)	d map zoelog v	nwaq Isalibani	LEBO	Α _	1.0	mAdc	
ON CHARACTERISTICS		s basileman	arti serro	100			
DC Current Gain (1)		beteluolan sa	T			T -	1

		Charles Programme		100000000000000000000000000000000000000	
(IC = 1.5 Adc, VCE = 2.0 Vdc)	2N5193		25	100	
obtained bear Figure 12	2N5194	10 4-20	25	100	
as a page on a portunitor				80	
(IC = 4.0 Adc, VCE = 2.0 Vdc)	2N5193	s steady st	10		
0	2N5194	elgms	10		
	2N5195	argina.	7.0	-	
Collector-Emitter Saturation Voltage (1)					Vdc
(IC = 1.5 Adc, IB = 0.15 Adc)	1 ms, tp = 0 5 ms 10	VCE(sat)	pts	0.6	
0	distribute and the CE of	ing Sign	61	1.4	
Base-Emitter On Voltage (1)	ra Di e 0.27	VBE(on)	100		Vdc
(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		- Congress	-	1.2	

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (IC = 1.0 Adc, VCE = 10 Vdc, f = 1.0 MHz)

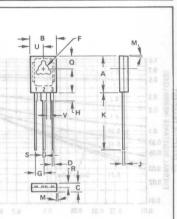
\*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width≤300 µs, Duty Cycle≤2.0%.

#### 4 AMPERE **POWER TRANSISTORS** SILICON PNP

40-80 VOLTS 40 WATTS





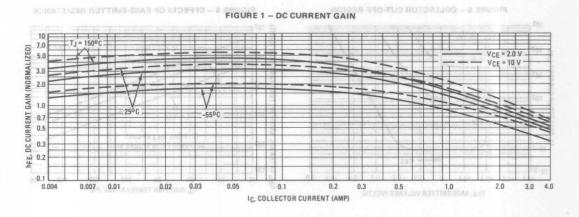
STYLE 1 PIN 1. EMITTER 2. COLLECTOR 3. BASE

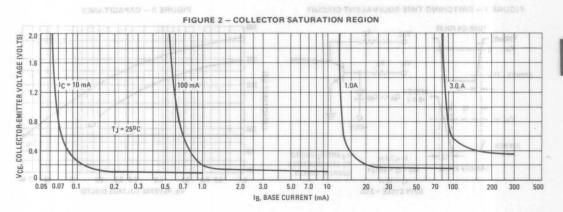
	MILLIMETERS		INCHES	
MID	MIN	MAX	MIN	MAX
Α	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	O TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-

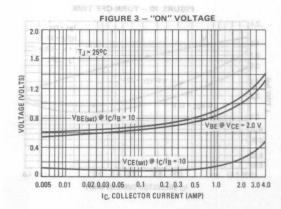
CASE 77-04 TO-126

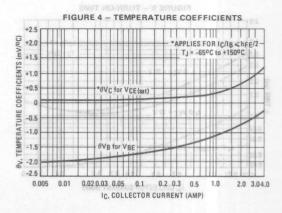
MHz

3-94

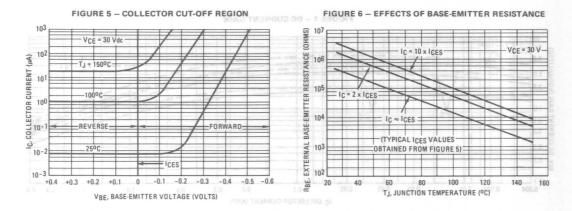












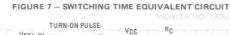
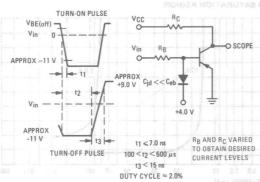
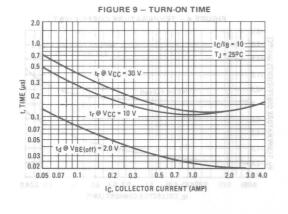
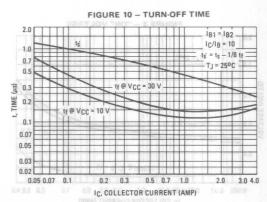


FIGURE 8 - CAPACITANCE 500 300 CAPACITANCE (pF) 200 100 Ccb . 50 0.2 0.3 0.5 1.0 2.0 3.0 5.0 10 VR, REVERSE VOLTAGE (VOLTS)



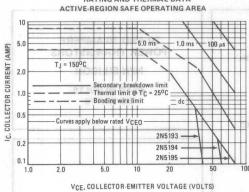




## ALOROTO



#### FIGURE 11 RATING AND THERMAL DATA

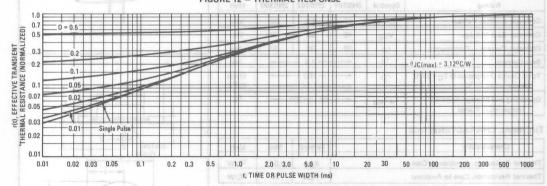


Note 1: MART MONEY MAN GRANGS HOL There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC - VCF limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

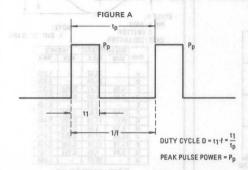
The data of Figure 11 is based on  $T_{J(pk)} = 150^{\circ}C$ .  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided T<sub>J</sub>(pk) ≤ 150°C. At high-case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second

Con. rements to PMP 2N4393, 2N4399 and 2N5745

#### FIGURE 12 - THERMAL RESPONSE



#### DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find  $\theta_{JC}(t)$ , multiply the value obtained from Figure 12 by the steady state value  $\theta_{JC}$ .

The 2N5193 is dissipating 50 watts under the following conditions:  $t_1$  = 0.1 ms,  $t_P$  = 0.5 ms. (D = 0.2).

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of  $r(t_1, D)$  is 0.27.

The peak rise in junction temperature is therefore:

 $\Delta T = r(t) \times Pp \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2^{\circ}C$ 



IT BRUDIS

KITA SESO ERAR MOLDER EL

#### HIGH-POWER NPN SILICON TRANSISTORS

... for use in power amplifier and switching circuits applications.

- High Collector-Emitter Sustaining Voltage BVCEO(sus) = 80 Vdc (Min) @ I<sub>C</sub> = 200 mAdc (2N5303)
- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 0.75 Vdc (Max) @ IC = 10 Adc (2N5301, 2N5302)
   1.0 Vdc (Max) @ IC = 10 Adc (2N5303)
- Excellent Safe Operating Area seel seafer of buildraft ed
   200 Watt dc Power Rating to 30 Vdc (2N5303) leads
- Complements to PNP 2N4398, 2N4399 and 2N5745

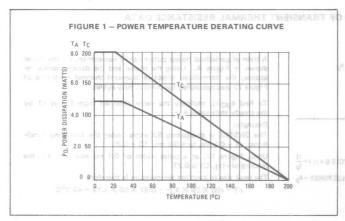
#### \*MAXIMUM RATINGS

Rating	Symbol	2N5301	2N5302	2N5303	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Collector Current — Continuous	I <sub>C</sub>	30	30	20	Adc
Base Current	IB	-	<del></del> 7.5		Adc
Total Device Dissipation @ T <sub>C</sub> =25°C Derate above 25°C	PD		— 200 — — 1.14 —		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +20	0	°C

#### THERMAL CHARACTERISTICS

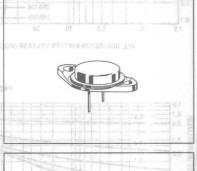
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ JC	0.875	°C/W
Thermal Resistance, Case to Ambient	θCA	34	°C/W

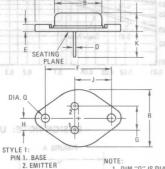
\*Indicates JEDEC Registered Data



# 20 AND 30 AMPERE POWER TRANSISTORS NPN SILICON

40-60-80 VOLTS 200 WATTS





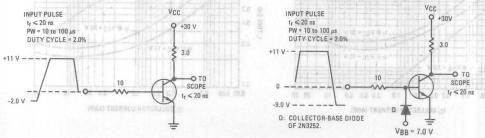
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR
MILLIMETERS
INCHES

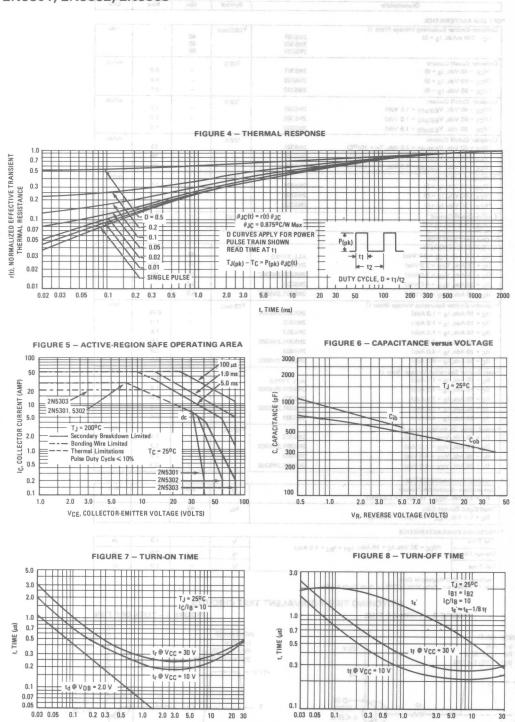
	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	_	39.37	1	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67	-	1.050

CASE 11-01 (TO-3)

3

	VCEO(sus)			Vdc	
2N5301	- CEO(sus)	40			
2N5302		60	-		
2N5303		80	-		
	ICEO			mAdc	
		-			
		-			
2N5303		-	5.0		
	ICEX			mAdc	
		-			
		-			
2N5303	100 - 100	5 at 1 at 1	1.0		
	CEX	Sec. 1		mAdc	
NAME AND POST OF THE PARTY OF T			10		0
(STEP HOUSE SHOPE IN LINE TO A STATE OF			10		
2N5303		THE ST	10		
	СВО			mAdc	
2N5301	1		1.0		
2N5302			1.0	7711	
2N5303			1.0	125	
2019 (8)2 =	IERO	141	5.0	mAdc	
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219301,219302		0.0	0.5 0.5		0.02 0.03 0.0
ONE 201 ONE 200	VCE (sat)		0.75	Vdc	
		-			
		_			
	ASSA D	DITABLE		ACTIVE-REGI	- a significant
		-			N VERNOR
2N5301,2N5302	10 es.007 - 13		3.0		
	VBE(sat)		fich is	Vdc	
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CARLOTTE STATE OF THE STATE OF		15.2	AND DESCRIPTION OF THE PERSON		
		AL PAIN			
2N5303		Tel 7- ob	2.5		
LLIons B	VBE(on)			Vdc	
2N5303	the state of	711	1.5	medstant years	1090
2N5301,2N5302	LILLIZI	M+1.	1.7	The state of the s	pp:
2N5303	FERE		2.5		
2N5301,2N5302	计算力	THE REAL PROPERTY.	3.0		
	TENTE	TITL	COME - IN		
		20	Take .	T	
TTT 081	The state of	2.0		MHZ	
- 2.0	003 03	40	. 51	3.0 8.0	
	nfe	181,10V) 36	NT JOV BRITIS	MA Adronation	aby year
1041)	tr	-	1.0	μs	
I.U Adc)	te	_	2.0	us	
		- 50017.9	3.5020117	-	
11111	tf	-	1.0	μs	
As .					Children of
OLUNIAL ENT TO	OT OLD O	HTC			
QUIVALENT TE	SI CIRCL	TOTAL TOTAL			MAKE
		FIGURE	3 - TURN	OFF TIME	
				VCC	
11	NPUT PULSE				
				0 +301/	
1 2 0.0	t <sub>r</sub> ≤ 20 ns PW = 10 to 100			9 +30V	
	2N5302 2N5303 2N5303 2N5301,2N5302 2N5301,2N5302 2N5301,2N5302 2N5301,2N5302 2N5301,2N5302 2N5301,2N5302 2N5301,2N5302 2N5303 2N5301,2N5302 2N5303 2N5301,2N5302 2N5303 2N5301,2N5302 2N5303 2N5301,2N5302	2N5301   ICEO   ICEO   2N5302   2N5303   ICEX   2N5303   ICEX   2N5303   ICEX   2N5303   ICEX   2N5301   ICEX   2N5302   2N5303   ICEO   ICEO	2N5301	CEO	CEO

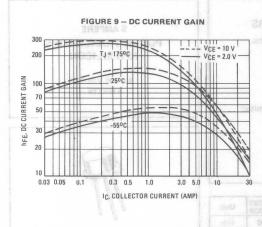


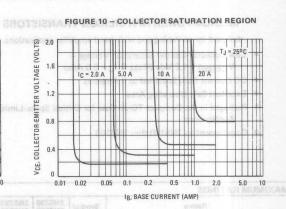


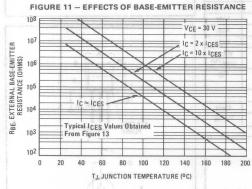
IC, COLLECTOR CURRENT (AMP)

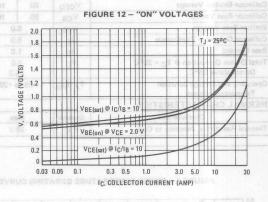
IC, COLLECTOR CURRENT (AMP)

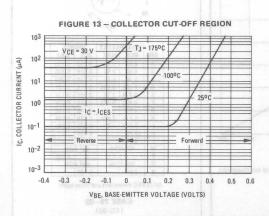
MOTOROLA

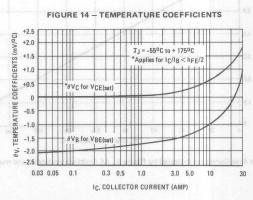














#### MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for switching and wide band amplifier applications.

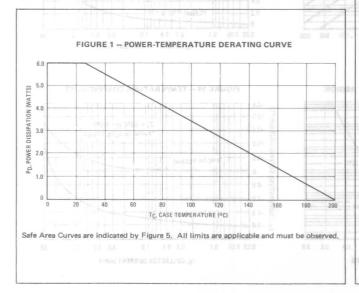
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 1.2 Vdc (Max) @ I<sub>C</sub> = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications
- Complement to 2N6190 thru 2N6193

#### **MAXIMUM RATINGS**

Rating	Symbol	2N5336 2N5337	2N5338 2N5339	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	6.0		Vdc
Collector Current — Continuous	Ic	5.0		Adc
Base Current	IB	1.0		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	6.0 34.3		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

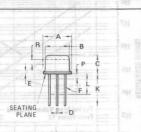
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	29.2	°C/W



# 5 AMPERE POWER TRANSISTORS NPN SILICON

80-100 VOLTS 6 WATTS





Q G G V O 1,2 O 1,

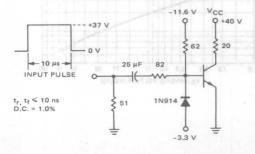
	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	8.89	9.40	0.350	0.370
В	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	-	0.500	
L	6.35	5	0.250	
M	450 N	MOI	450 N	OM
P	-	1.27	-	0.050
0	900 V	MOI	90° NOM	
R	2.54	-	0.100	

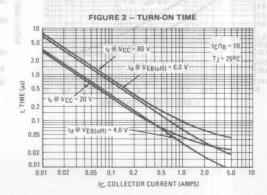
All JEDEC dimensions and notes apply.

CASE 79-02 (TO-39)

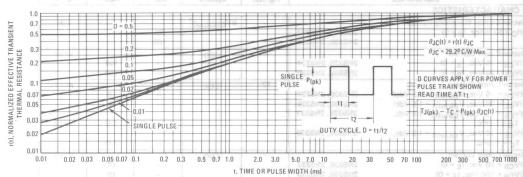
Characteristic			Fig. No.	Symbol	Min	Max	Unit
OFF CHARA	CTERISTICS			- Harris and Alberta			
Collector-Emi	tter Sustaining Voltage*			BVCEO(sus)*	4 - 1 - 1		Vdc
$(I_C = 50 \text{ m})$	Adc, I <sub>B</sub> = 0)	2N5336, 2N5337			80	-	
		2N5338, 2N5339			100		
Collector Cuto	off Current			ICEO	Secretary or Assessment		μAdc
(V <sub>CE</sub> = 75	Vdc, I <sub>B</sub> = 0)	2N5336, 2N5337				100	
(VCE = 90	Vdc, IB = 0)	2N5338, 2N5339	102			100	
Collector Cuto	off Current	1 (up) 383	12	ICEX	White I am	14,1	μAdc
(VCF = 75	Vdc, VER(off) = 1.5 Vde)	2N5336, 2N5337		OLX	-	10	
	Vdc, VEB(off) = 1.5 Vdc)	2N5338, 2N5339				10	
	Vdc, VEB(off) = 1.5 Vdc,	2N5336, 2N5337			10.0	1	
TC = 150					- 38.45 <del>/1</del> 3.16/HB	1.0	mAdc
	Vdc, VEB(off) = 1.5 Vdc,	2N5338, 2N5339			36307 33000		
TC = 150						1.0	
Collector Cuto	off Current		tek <u>l</u> utek	Ісво		212000	μAdc
	Vdc, I = 0)	2N5336, 2N5337	2.0 3.0	LCBO I	0 20 10	10	Arido
00	0 Vdc, I <sub>E</sub> = 0)	2N5338, 2N5339	HAE OR PUESS	3		10	
		2140006, 2140000		1		10	A
Emitter Cutof			-	IEBO		400	μAdc
	0 Vdc, I <sub>C</sub> = 0)					100	
ON CHARAC			, AB	PERATING ARE	HON SAFE D	ACTIVE REG	- 1 380
DC Current G	ain*		8	hFE*			-
(I <sub>C</sub> = 500 i	mAdc, V <sub>CE</sub> = 2.0 Vdc)	2N5336, 2N5338	E E		30		
	trutanago strio minui motilar	2N5337, 2N5339	一	100.001	60		
(IC = 2.0 A	Adc, VCE = 2.0 Vdc)	2N5336, 2N5338	111		30	120	
	ACE limits of the renzistor	2N5337, 2N5339		200 11.1	60	240	
$I_{C} = 5.0 A$	Adc, VCE = 2.0 Vdc)	2N5336, 2N5338	1		20	2 -	
		2N5337, 2N5339		JA DATE	40		
Collector-Emi	tter Saturation Voltage*	The date of Pi	9, 11, 13	VCE(sat)*			Vdc
	Adc, I <sub>B</sub> = 0.2 Adc)		11	02,000	1 - 1	0.7	
(IC = 5.0 A	Adc, IB = 0.5 Adc)		12	Design Berry	nid nivelident ye	1.2	
Base-Emitter S	Saturation Voltage*	Vided L1(pk) ≤ 19U	11,13	VBE(sat)*	barmil envi	доново — -	Vdc
	Ado In = 0.2 Ado)		117.18	DE(Sat)	Contrations 1.0 1	0 1.2	
	Adc, I <sub>B</sub> = 0.5 Adc)		- 算	0.0	is for Potent B.V.o.	1.8	
		the limitetions in		T ZHOOM, 37 July			
		chowns .	1 (2)	A Table of Barrier 1			1411-
	Bandwidth Product		160	gg T <sup>†</sup> gg 70	30		MHz
	Adc, V <sub>CE</sub> = 10 Vdc, f = 10 MHz)			(2T (N/A 22	30	COLUMN TO SECTION I	lov Ver
Output Capac			7	Cob			pF
	Vdc, I <sub>E</sub> = 0, f = 100 kHz)			Marine Control	-	250	
Input Capacitance			7	Cib			pF
	0 Vdc, I <sub>C</sub> = 0, f = 100 kHz)	- ranuara		31/1	TURNZOFF	1,000	
	CHARACTERISTICS						
Delay Time	(VCC = 40 Vdc, VEB(off) = 3.0 V	/dc,	2,3	t <sub>d</sub>	-	100	ns
Rise Time	(I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 0.2 Adc)	93		t <sub>r</sub>	UTILITY OF	100	ns
Storage Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc,		2,6			2.0	1
			2,0	t <sub>s</sub>		233	μs
Fall Time I <sub>B1</sub> = I <sub>B2</sub> = 0.2 Adc)			2 - 1	tf	-	200	ns



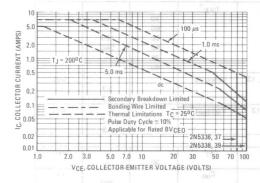








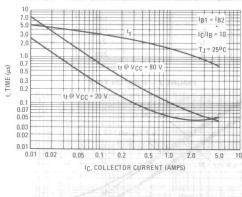
#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



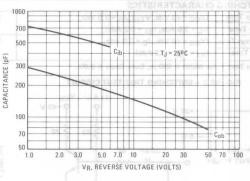
There are two limitations on the power han- bam 002 a gill dling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate,

The data of Figure 5 is based on  $T_J(pk) = 200^{\circ}C$ ;  $T_C$  is variable depending on conditions, vided T  $_{J(pk)} \leq 200^{o} \text{C}.$  T  $_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary break-

#### FIGURE 6 - TURN-OFF TIME

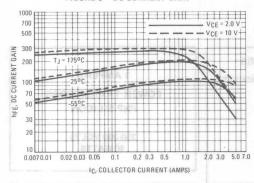


#### FIGURE 7 - CAPACITANCE versus VOLTAGE

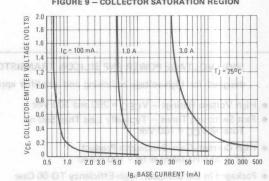




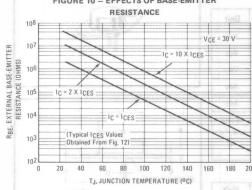




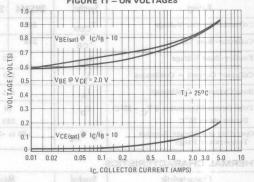
#### FIGURE 9 - COLLECTOR SATURATION REGION



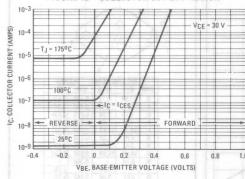
# FIGURE 10 - EFFECTS OF BASE-EMITTER



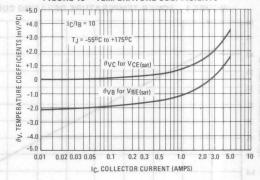
# FIGURE 11 - ON VOLTAGES



#### FIGURE 12 - COLLECTOR CUT-OFF REGION



#### FIGURE 13 - TEMPERATURE COEFFICIENTS





HIGH VOLTAGE POWER PNP SILICON TRANSISTORS

. . . designed for high-voltage switching and amplifier applications.

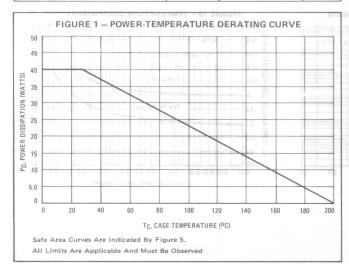
- High Voltage Ratings VCEO = 250 and 300 Vdc
- Fast Switching Times Typically Less Than 550 ns
  Total @ VCC = 100 Vdc
- High Current-Gain-Bandwidth Product fT = 60 MHz (Min) @ IC = 100 mAdc
- Packaged in the Compact, High-Efficiency TO-66 Case

#### MAXIMUM RATINGS

Rating	Symbol	2N5344	2N5345	Unit
Collector-Emitter Voltage	v <sub>CEO</sub>	250	300	Vdc
Collector-Base Voltage	v <sub>CB</sub>	250	300	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	5. 0		Vdc
Collector Current - Continuous	I <sub>C</sub> V S 28V	1.0		Adc
Base Current - Continuous	IB	0.5		Adc
Total Device Dissipation @ T <sub>C</sub> = 25° C Derate above 25° C	P <sub>D</sub>	228		Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

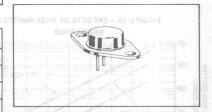
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	4.38	°C/W

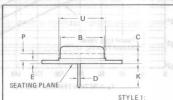


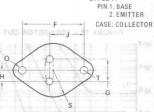
1 AMPERE

POWER TRANSISTORS
PNP SILICON

250-300 VOLTS 40 WATTS







	MILLI	METERS	IN	CHES
MIC	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
1	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
(	9.14	-	0.360	-
)	02118	1.27	SILA	0.050
1	3.61	3.86	0.142	0.152
3	-	8.89	-	0.350
Γ.	-	3.68	-	0.145
J	-	15.75	-	0.620

All JEDEC Dimensions and and Notes Apply.

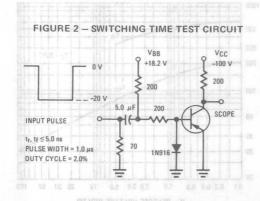
CASE 80-02

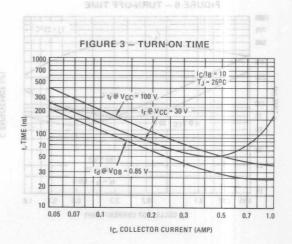
3

	Characteristic	FG. DF FL	Fig. No.	Symbol	Min	Max	Unit
OFF CHARA	CTERISTICS						Ε.0
	itter Sustaining Voltage (1) Adc, I <sub>B</sub> = 0) (1)	2N5344 2N5345	5	VCEO(sus)	250 300	1.0	Vdc s.0
(V <sub>CE</sub> = 225 (V <sub>CE</sub> = 270 (V <sub>CE</sub> = 225 T <sub>C</sub> = 150	Vdc, VBE(off) = 1.5 Vdc,	2N5344 2N5345 2N5344 2N5345	2.109 10, 12	ICEX		100 100	μAdc (60)
Collector Cut		8.0 10	1,0 2,0 3,0	СВО		80.00.10.0	mAdc 10.0
Emitter Cutor (V <sub>BE</sub> = 5.0	ff Current Vdc, I <sub>C</sub> = 0)		- time	IEBO	_	0.1	mAdc
ON CHARA	CTERISTICS		IING AREA	SAFE OFERAT	NOIDER	- ACTIVE-	e anuais
	Gain (1) nAdc, V <sub>CE</sub> = 5.0 Vdc) dc, V <sub>CE</sub> = 5.0 Vd¢)		8	hFE	25 7.0	150	<b>有</b> 加
	itter Saturation Voltage dc, I <sub>B</sub> = 0.2 Adc)		9, 11, 13	VCE(sat)		3.0	Vdc
	Saturation Voltage dc, I <sub>B</sub> = 0.2 Adc)	There are two enciclor: junct fe coercine an	11, 13	VBE(sat)	MI,	1.5	Vdc
DYNAMIC (	CHARACTERISTICS		Hit .				
	n—Bandwidth Product nAdc, V <sub>CE</sub> = 20 Vdc, f = 10 MHz)	dicure. The data of Fi		fT/-m/	60		MHz
Output Capa (V <sub>CB</sub> = 10 '	citance Vdc, I <sub>E</sub> = 0)	ale depending or bles of 1835 pro- me from the de	7	C <sub>ob</sub>	HEF	200	pF 00
			rh //	MEHAI		LASTRE YE AGE.	1072 SEDI
Turn-On	(V <sub>CC</sub> = 100 Vdc, I <sub>C</sub> = 500 mA I <sub>B1</sub> = I <sub>B2</sub> = 50 mAdc)	idc,	2, 3	ton		200	ns man
Turn-Off	(V <sub>CC</sub> = 100 Vdc, I <sub>C</sub> = 500 m/ I <sub>R1</sub> = I <sub>R2</sub> = 50 mAdc)	Adc,	2, 6	toff	70 19	700	ns

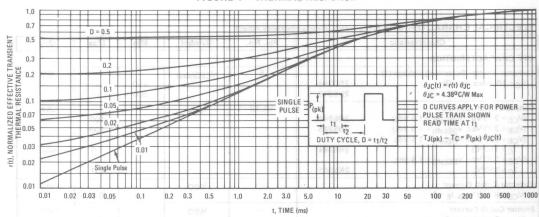
<sup>(1)</sup> Pulse Test: Pulse Width  $\approx$  300  $\mu$ s, Duty Cycle  $\approx$  2.0%.

 $I_{B1} = I_{B2} = 50 \text{ mAdc}$ 

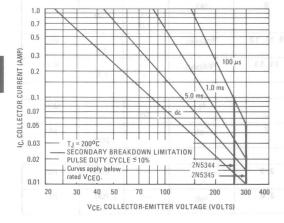








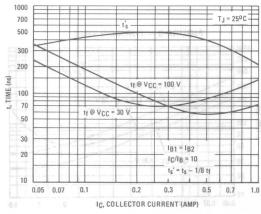
#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



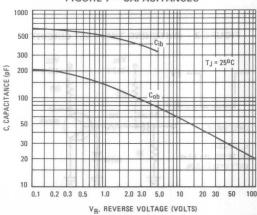
There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>C</sub>E limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_C$  is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided  $T_{J(pk)} \leq 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

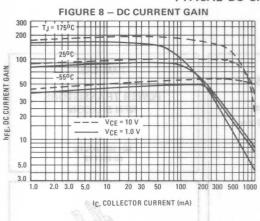
#### FIGURE 6 - TURN-OFF TIME

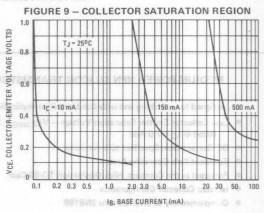


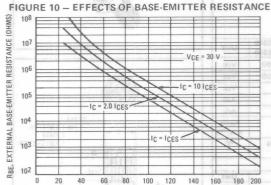
#### FIGURE 7 - CAPACITANCES



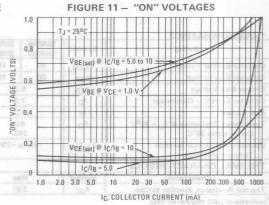
#### TYPICAL DC CHARACTERISTICS

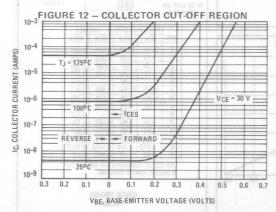


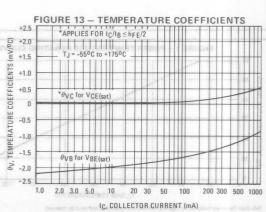




TJ, JUNCTION TEMPERATURE (°C)









# MEDIUM-POWER NPN SILICON TRANSISTORS

... designed for switching and wide-band amplifier applications.

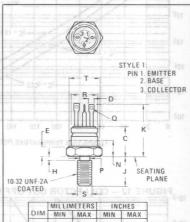
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.2 Vdc (Max) @ IC = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration
- Complementary to 2N6186 thru 2N6189

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BASE-E		3999	RE 10
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		11	

Rating	Symbol	2N5346 2N5347	2N5348 2N5349	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	80	100	Vdc
Emitter-Base Voltage	VEB	6	0.0	Vdc
Collector Current — Continuous	1 <sub>C</sub>	7	.0	Adc
Base Current	I <sub>B</sub>	6.1	.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		43	Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	o +200	°C
THERMAL CHARACTERISTICS			×	
Characteristic	Symbol	M	lax	Unit
Thermal Resistance, Junction to Case	θ.IC	2.	.91	°C/W

\*Indicates JEDEC Registered Data.



DIM	MIN	MAX	MIN	MAX
В	10.77	11.10	0.424	0.437
C	8.13	11.89	0.320	0.468
E	2.29	3.81	0.090	0.150
G	4.70	5.46	0.185	0.215
H	-	1.98	4-	0.078
J	10.16	11.56	0.400	0.455
K	14.48	19.38	0.570	0.763
L	2.29	2.79	0.090	0.110
N	-	6.35		0.250
P	4.14	4.80	0.163	0.189
0	1.02	1.65	0.040	0.065
R	8.08	9.65	0.318	0.380
S	4.212	4.310	0.1658	0.1697
T	9.65	11.10	0.380	0.437

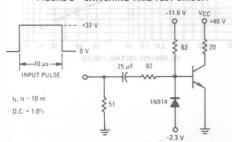
CASE 160-03

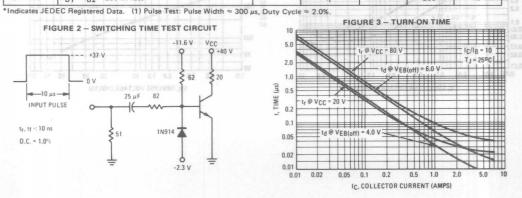
50					0.1+ =	
			111 L	el cult	-0.5	
40	1111	-		tracelly than to	8 8	THE VE
30	-				- 2.0	
20						
10			114			
10			10002.00		B -2.8 -	
0 20	40	60 8	0 100	120	140 160	180

HILL	Characteristic		Fig. No.	Symbol	Min	Max	Unit
FF CHARA	CTERISTICS		177546			THE REL	
	tter Sustaining Voltage (1) Adc, I <sub>B</sub> = 0)	2N5346, 2N5347 2N5348, 2N5349		VCEO(sus)	80 100		Vdc
	The state of the s	2N5346, 2N5347 2N5348, 2N5349		ICEO	-	100 100	μAdc
(V <sub>CE</sub> = 90 (V <sub>CE</sub> = 75 T <sub>C</sub> = 15	Vdc, VEB(off) = 1.5 Vdc) Vdc, VEB(off) = 1.5 Vdc) Vdc, VEB(off) = 1.5 Vdc, Vdc, VEB(off) = 1.5 Vdc, 0°C) Vdc, VEB(off) = 1.5 Vdc,	2N5346, 2N5347 2N5348, 2N5349 2N5346, 2N5347 2N5348, 2N5349	0.0 0.5 MAT 1	ICEX	E.0 £8	10 10 1.0	μAdc
Collector Cuto		2115546, 2115549	-	ІСВО	_	10	μAdc
Emitter Cutof			-	BRA EBOTARS	ON SAFE OF	100	μAdc
ON CHARAC	TERISTICS (1)	t a by otilicis enith			717		
(I <sub>C</sub> = 500 r	ain mAdc, V <sub>CE</sub> = 2.0 Vdc) Adc, V <sub>CE</sub> = 2.0 Vdc) Adc, V <sub>CE</sub> = 2.0 Vdc)	2N5346, 2N5348 2N5347, 2N5349 2N5346, 2N5348 2N5347, 2N5349 2N5346, 2N5348	8	100 E	30 60 30 60 20 40	120 240	
(IC = 2.0 A	tter Saturation Voltage Adc, I <sub>B</sub> = 0.2 Adc) Adc, I <sub>B</sub> = 0.7 Adc)	Pulse corves are vi	9, 11, 13	VCE(sat)		0.7 1.2 2.109	Vdc
Base-Emitter S (I <sub>C</sub> = 2.0 A (I <sub>C</sub> = 7.0 A	Saturation Voltage Adc, I <sub>B</sub> = 0.2 Adc) Adc, I <sub>B</sub> = 0.7 Adc)	top and most bals!	11,13	VBE(sat)	01	1.2 2.0	Vdc
Current-Gain-	-Bandwidth Product mAdc, V <sub>CE</sub> = 10 Vdc, f = 10 M	Hz)	-	f <sub>T</sub>	30	NA SOTOR EN	MHz
Output Capac			7	C <sub>ob</sub>	et amount	250	pF
	0 Vdc, I <sub>C</sub> = 0, f = 100 kHz)		7	Cib	Mall	1,000	pF
	CHARACTERISTICS			ETT BOOK		P T	HEELS.
Delay Time Rise Time	(V <sub>CC</sub> = 40 Vdc, V <sub>EB</sub> (off) = 3 (I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 200 mAc		2,3	t <sub>d</sub>		100	ns
Storage Time Fall Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 200 mAdc)		2,6	t <sub>s</sub>	11 H 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2.0	μs ns

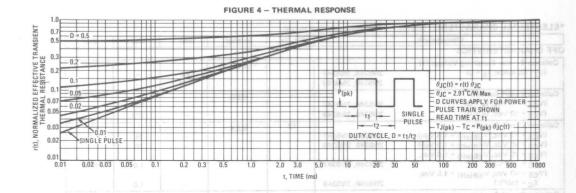
FIGURE 4 - THERMAL RESPONSE

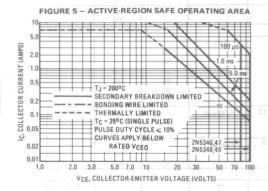








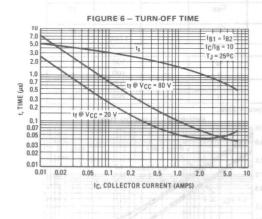


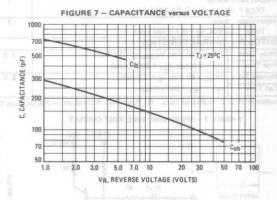


There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub> – V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions.

Pulse curves are valid for duty cycles of  $10^{\circ}$  provided  $T_{J(pk)} \leq 200^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary





0.02 0.03 0.05

0.1



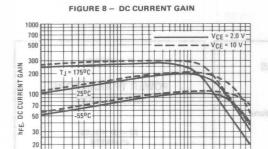
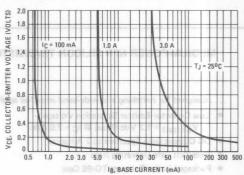


FIGURE 9 - COLLECTOR SATURATION REGION





IC, COLLECTOR CURRENT (AMPS)

0.2 0.3 0.5 1.0

2.0 3.0 5.0 7.0

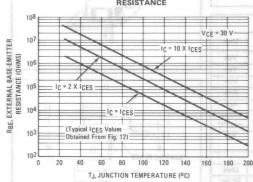


FIGURE 11 - "ON" VOLTAGES

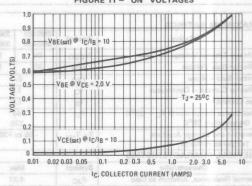


FIGURE 12 - COLLECTOR CUT-OFF REGION

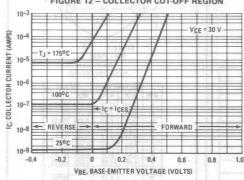
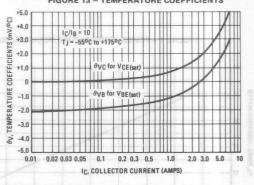


FIGURE 13 - TEMPERATURE COEFFICIENTS





WILL BE WOLLAND LAS MOLDS JUDIO - C SECON

Har I

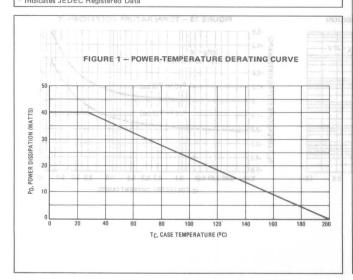
#### MEDIUM-POWER NPN SILICON TRANSISTORS

... designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 1.2 Vdc (Max) @ IC = 7.0 Adc
- DC Current Gain Specified to 7 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-66 Case

SHOUTHON "ON" - IT SHIDES

*MAXIMUM RATINGS		The second second		12 000
Rating	Symbol	2N5427 2N5428	2N5429 2N5430	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	6	.0	Vdc
Collector Current — Continuous	Ic	7	.0	Adc
Base Current	IB	1	.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		0	Watts mW/OC
Operating and Storage Junction Temperature Range	TJ, Tstg	-65 to	+200	°C
THERMAL CHARACTERISTICS		minutes 0		ine and
Characteristic	Symbol	M	ax	Unit
Thermal Resistance, Junction to Case	θJC	4.	37	°C/W

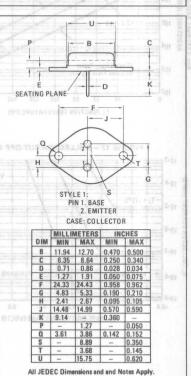


7 AMPERE

# POWER TRANSISTORS NPN SILICON

80-100 VOLTS 40 WATTS





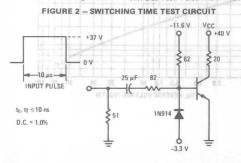
CASE 80-02 TO-66

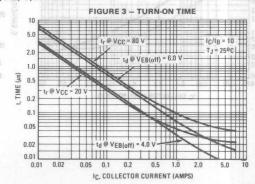
3

*ELECTRICAL CHARACTERISTICS (To = 25°C, unless otherwise not	Ibe

	Characteristic		Fig. No.	Symbol	Min	Max	Unit
FF CHARA	CTERISTICS					141111	
	tter Sustaining Voltage (1) nAdc, I <sub>B</sub> = 0)	2N5427, 2N5428 2N5429, 2N5430		BV <sub>CEO(sus)</sub> *	80 100	0.0 - 0 	Vdc
	off Current 5 Vdc, I <sub>B</sub> = 0) ) Vdc, I <sub>B</sub> = 0)	2N5427, 2N5428 2N5429, 2N5430	1418 1418	ICEO		100	μAdc
(V <sub>CE</sub> = 75 (V <sub>CE</sub> = 90	off Current (1.5 Vdc) 5 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc) 5 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc) 5 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc,	2N5427, 2N5428 2N5429, 2N5430	12	ICEX	- 10	10 10	μAdc
T <sub>C</sub> = 15	50°C) ) Vdc, V <sub>EB(off)</sub> = 1.5 Vdc,	2N5427, 2N5428 2N5429, 2N5430			32,104,33986	1.0	mAdd
Collector Cut	Tierry with the color of the color	05 05 01 0.1 0.0 (am) HTQ1	9.6 _ 9.6 9.6 _ 9.6 9.6	СВО	0 80 1	10	μAdo
	0 Vdc, I <sub>C</sub> = 0)		-	IEBO	-	100	μAdc
ON CHARAC	CTERISTICS (1)	AREA OPERATING AREA	REGION SA	BVITOA - B BRI	WOLES		
(I <sub>C</sub> = 2.0 A	ann MAdc, V <sub>CE</sub> = 2.0 Vdc) Adc, V <sub>CE</sub> = 2.0 Vdc) Adc, V <sub>CE</sub> = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430 2N5427, 2N5429 2N5428, 2N5430 2N5427, 2N5429 2N5428, 2N5430	8	hFE*	30 60 30 60 20 40	120 240	35.05-4
$(I_C = 2.0)$	tter Saturation Voltage Adc, I <sub>B</sub> = 0.2 Adc) Adc, I <sub>B</sub> = 0.7 Adc)	The date of Figure 200°C; To is variable of Poles curves are valid for vided T varia < 200°C.	9, 11, 13	VCE(sat)*	hatimi J riwote batter batter and	0.7 1.2	Vdc
(I <sub>C</sub> = 2.0 / (I <sub>C</sub> = 7.0 /	Saturation Voltage Adc, I <sub>B</sub> = 0.2 Adc) Adc, I <sub>B</sub> = 0.7 Adc)	peratures, thermal liming power that can be han	11,13	VBE(sat)*	1 - 111 - 111	1.2 2.0	Vdc
	HARACTERISTICS	moon	- 3				
(I <sub>C</sub> = 500	-Bandwidth Product mAdc, V <sub>CE</sub> = 10 Vdc, f = 10 MI	Hz)	- 901	127 (01) 12	30	30 50 7K	MHz
	) Vdc, I <sub>E</sub> = 0, f = 100 kHz)		7	Cob	_	250	pF
	0 Vdc, I <sub>C</sub> = 0, f = 100 kHz)	FIGURE 7 — CA	7	C <sub>ib</sub>	130-KRUT	1,000	pF
	CHARACTERISTICS		p) g	-		-	
Delay Time Rise Time	(V <sub>CC</sub> = 40 Vdc, V <sub>EB(off)</sub> = 3. (I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 200 mAd		2,3	t <sub>d</sub>		100	ns
Storage Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc,		2,6	t <sub>s</sub>		2.0	μs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 200 mAdc)		12	tf		200	ns

\*Indicates JEDEC Registered Data. (1) Pulse Test: Pulse Width ≈ 300 µs, Duty Cycle ≈ 2.0%.

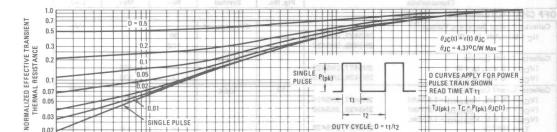




0.01

0.01

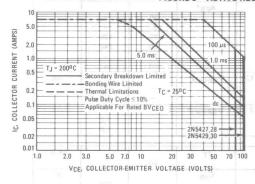
200 300 500 700 1000



#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA

t, TIME OR PULSE WIDTH (ms)

2.0 3.0 5.0 7.0 10



0.2 0.3

0.5 0.7 1.0

0.02 0.03 0.05 0.07 0.1

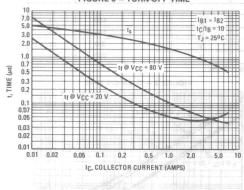
There are two limitations on the power handing ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

20 30

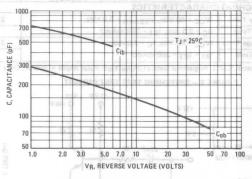
FIGURE 4 - THERMAL RESPONSE W JOSES - 571 BOTTOR RETURN JACKSTONE

The data of Figure 5 is based on  $T_J(pk)$  =  $200^{\circ}C$ ;  $T_C$  is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided  $T_J(pk) \leq 200^{\circ}C$ .  $T_J(pk)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary break-down.

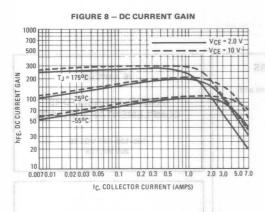
#### FIGURE 6 - TURN-OFF TIME

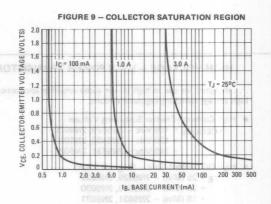


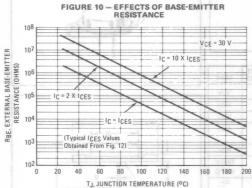
#### FIGURE 7 - CAPACITANCE versus VOLTAGE

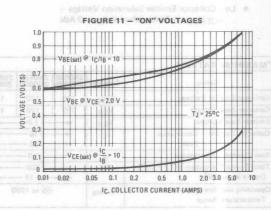


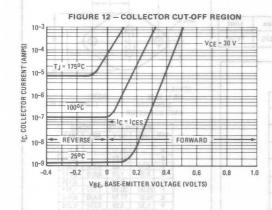


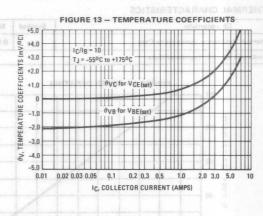














2N5427 thru 2N5430

# HIGH-VOLTAGE - HIGH POWER TRANSISTORS

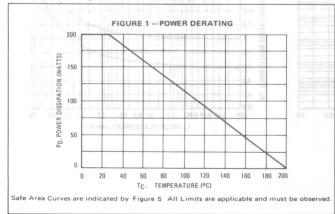
. designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage
  - VCEO(sus) = 100 Vdc 2N5629, 2N6029 = 120 Vdc 2N5630, 2N6030
    - = 140 Vdc 2N5631, 2N6031
- High DC Current Gain @ IC = 8.0 Adc  $h_{FF} = 25 \text{ (Min)} - 2N5629, 2N6029$ 
  - = 20 (Min) 2N5630, 2N6030
  - = 15 (Min) 2N5631, 2N6031
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 10 Adc

*MAXIMUM RATINGS					
Rating	Symbol	2N5629 2N6029	2N5630 2N6030	2N5631 2N6031	Unit
Collector-Emitter Voltage	VCEO	100	120	140	Vdc
Collector-Base Voltage	VCB	100	120	140	Vdc
Emitter-Base Voltage	VEB	-	7.0	-	Vdc
Collector Current - Continuous Peak	¹c	-	— 16 — — 20 —		Adc
Base Current - Continuous	I IB	10)3.	5.0	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	100 to 10	200 1.14 _	- 001	Watts W/OC
Operating and Storage Junction 13 700 13 Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +20	00	°C

#### \*THERMAL CHARACTERISTICS

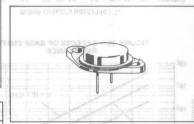
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	#JC	0.875	°C/W

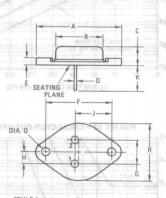


#### 16 AMPERE

### POWER TRANSISTORS COMPLEMENTARY SILICON

100-120-140 VOLTS 200 WATTS





STYLE 1: PIN 1. BASE 2. EMITTER

NOTE: 1. DIM "Q" IS DIA.

	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A		39.37		1.550	
В		21.08		0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	2.87331	3.43	350	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	-	26.67	-	1.050	
		r connecte		2.	

# 2N5629, 2N5630, 2N5631 NPN 2N6029, 2N6030, 2N6031 PNP

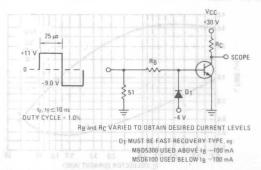
2N6029, 2N6030, 2N6031 PNP

#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I C = 200 mAdc, I B = 0) 2N5629, 2N6029 2N5630, 2N6030 2N5631, 2N6031	VCEO(sus)	100 120 140	-	Vdc
Collector-Emitter Cutoff Current     2N5629, 2N6029       (VCE = 50 Vdc, IB = 0)     2N5630, 2N6030       (VCE = 60 Vdc, IB = 0)     2N5631, 2N6031	CEO		1.0 1.0 1.0	mAdc
Collector-Emitter Cutoff Current (VCE = Rated VCB, VEB(off) = 1.5 Vdc) (VCE = Rated VCB, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEX	11-	1.0 5.0	mAdc
Collector-Base Cutoff Current (VCB = Rated VCB, IE = 0)	СВО	11-12	1.0	mAdc
Emitter-Base Cutoff Current (V <sub>BE</sub> = 7.0 Vdc, I <sub>C</sub> = 0)	<sup>1</sup> EBO		1.0	mAdc
ON CHARACTERISTICS (1) as as as as as	0.5 0.1	an s	Ø (0 80	80.0
DC Current Gain (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 2.0 Vdc)  2N5629, 2N6029 2N5630, 2N6030 2N5631, 2N6031 (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 2.0 Vdc)  All Types		25 20 15 4.0	100 80 60	-
Collector-Emitter Saturation Voltage ( $I_C = 10 \text{ Adc}, I_B = 1.0 \text{ Adc}$ ) All Types ( $I_C = 16 \text{ Adc}, I_B = 4.0 \text{ Adc}$ )	VCE (sat)	Ma I	1.0	Vdc
Base-Emitter Saturation Voltage some notice spread to the set of t	V <sub>BE</sub> (sat)	7	1.8	Vdc
Base-Emitter On Voltage (IC = 8.0 Adc, VCE = 2.0 Vdc)	V <sub>BE</sub> (on)	GETTENS MINO		Vdc
DYNAMIC CHARACTERISTICS		A Jest - Statist	WHI ATTYWEEN LA	-
Current-Gain-Bandwidth Product (2) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 20 Vdc, f <sub>test</sub> = 0.5 MHz)	fT	1.0	1755 AP <u>21</u> Y BELOW NATED VCED	MHz
Output Capacitance         2N5629, 30, 31           (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)         2N6029, 30, 31	C <sub>ob</sub>	ZWSBSB, ZWSBSB ZWSBSB ZWSBSB ZWSBSD1, ZWBSD1	500 1000	pF
Small-Signal Current Gain ( $I_C = 4.0 \text{ Adc}$ , $V_{CE} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	h <sub>fe</sub>	15	5.0 7.0 10	0. 0.5

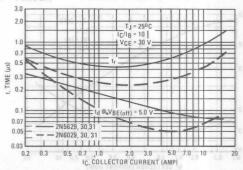
<sup>\*</sup>Indicates JEDEC Registered Data.

#### FIGURE 2 - SWITCHING TIMES TEST CIRCUIT 330 MADY - 3 BRUDIS



For PNP test circuit, reverse all polarities and D1.

#### FIGURE 3 - TURN-ON TIME



<sup>(1)</sup> Pulse Test: Pulse Width  $\leqslant$  300  $\mu s$ , Duty Cycle  $\geqslant$  2.0%. (2) f\_T = |h\_{fe}| • f\_{test}



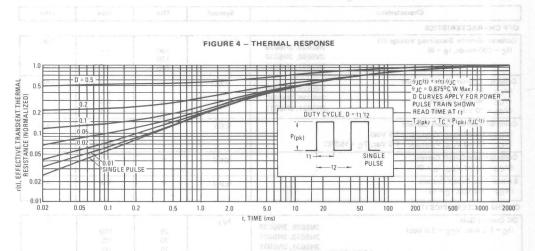
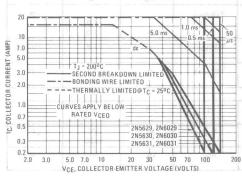


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



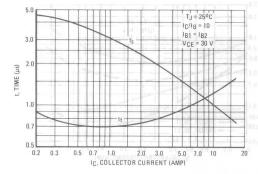
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

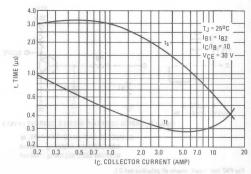
must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on  $T_J(p_k)=200^{o}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(p_k) \leqslant 200^{o}C$ .  $T_J(p_k)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

NPN 2N5629, 2N5630, 2N5631

PNP 2N6029, 2N6030, 2N6031

DOUBE 2 - SWITCHING TIMES TEST CHEMIT FOORNUT - 6 BRUDIF





NPN 2N5629, 2N5630, 2N5631

PNP 2N6029, 2N6030, 2N6031

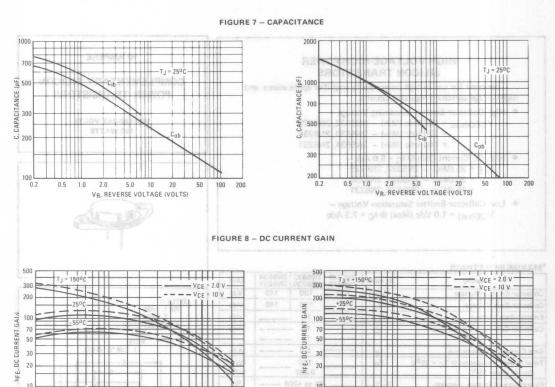
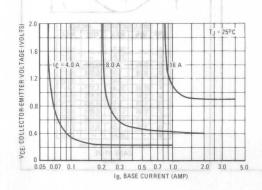


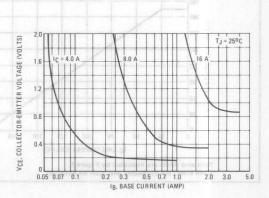
FIGURE 9 - COLLECTOR SATURATION REGION



0.5 0.7 1.0

2.0 3.0

IC. COLLECTOR CURRENT (AMP)



2.0 3.0 5.0 7.0

IC. COLLECTOR CURRENT (AMP)

3



#### HIGH VOLTAGE-HIGH-POWER SILICON TRANSISTORS

designed for use in high power audio amplifier applications and high-voltage switching regulator circuits.

High Collector-Emitter Sustaining Voltage -

VCEO(sus) = 100 Vdc (Min) - 2N5632, 2N6229 = 120 Vdc (Min) - 2N5633, 2N6230

= 140 Vdc (Min) - 2N5634, 2N6231

High DC Current Gain @ I<sub>C</sub> = 5.0 Adc – hFE = 25 (Min) – 2N5632, 2N6229

= 20 (Min) - 2N5633, 2N6230 = 15 (Min) - 2N5634, 2N6231

 Low Collector-Emitter Saturation Voltage — VCE(sat) = 1.0 Vdc (Max) @ IC = 7.5 Adc

#### 10 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

100-120-140 VOLTS 150 WATTS



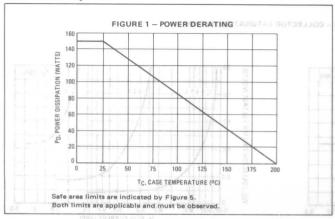
\*MAVIBALISA DATISICO

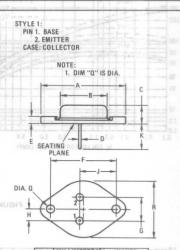
WAXIVIUW RATINGS			with the same of t		-
Rating	Symbol	2N5632 2N6229	2N5633 2N6230	2N5634 2N6231	Unit
Collector-Emitter Voltage	VCEO	100	120	140	Vdc
Collector-Base Voltage	VCB	100	120	140	Vdc
Emitter-Base Voltage	VEB	-500	7.0		Vdc
Collector Current — Continuous — Peak	lc		-01 10 - -015 -		Adc
Base Current - Continuous	IB	-	- 5.0 -		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	-	150 0.857		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +20	00	°C

### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W

\*Indicates JEDEC Registered Data.



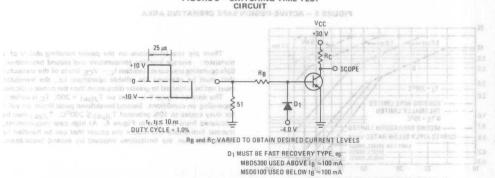


	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
A		39.37		1.550
В	+	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	+	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
3	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67	-	1.050

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage <sup>(1)</sup> (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0) 2N5632, 2N6229 2N6633, 2N6230 2N5634, 2N6231	VCEO(sus)	100 120 140	71 - 24 00	Vdc
Collector-Emitter Cutoff Current  (VCE = 50 Vdc, I <sub>B</sub> = 0) 2N5632, 2N6229  (VCE = 60 Vdc, I <sub>B</sub> = 0) 2N5633, 2N6230  (VCE = 70 Vdc, I <sub>B</sub> = 0) 2N5634, 2N6231  Collector-Emitter Cutoff Current	ICEO		1.0 1.0 1.0	mAdo
(VCE = Rated VCB, VEB(off) = 1.5 Vdc) (VCE = Rated VCB, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEX	1 - 1	1.0 5.0	made
Collector Base Cutoff Current (VCB = Rated VCB, IE = 0)	СВО		1.0	mAdo
Emitter-Base Cutoff Current (VBE = 7.0 Vdc, IC = 0)	IEBO		1.0	mAdo
ON CHARACTERISTICS		CORRESOT LABOR	SOUTH COLUMN	
DC Current Gain <sup>(1)</sup> (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 2.0 Vdc) 2N5632, 2N6229 2N5633, 2N6230 2N5634, 2N6231 (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 2.0 Vdc) All Types	hFE	25 20 15 5.0	100 80 60	Ī
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>B</sub> = 0.75 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc)	VCE(sat)	-	1.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>B</sub> = 0.75 Adc)	VBE(sat)		2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		1.5	Vdc
PYNAMIC CHARACTERISTICS		100	HILLIAN	an 0
Current-Gain-Bandwidth Product (2) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 20 Vdc, f <sub>test</sub> = 0.5 MHz)	fT	1.0		MHz
Output Capacitance 2N5632, 2N5633, 2N5634 (VCB = 10 Vdc, IE = 0, f = 0.1 MHz) 2N6229, 2N6230, 2N6231	C <sub>ob</sub>		300 600	pF
Small Signal Current Gain (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> = 2.0 Adc, f = 1.0 kHz)	h <sub>fe</sub>	15		1 1

<sup>\*</sup>Indicates JEDEC Registered Data.

# FIGURE 2 - SWITCHING TIME TEST



For PNP test, reverse all polarities and D1.

3

<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

<sup>(2)</sup> f<sub>T</sub> = | h<sub>fe</sub>| • f<sub>test</sub>

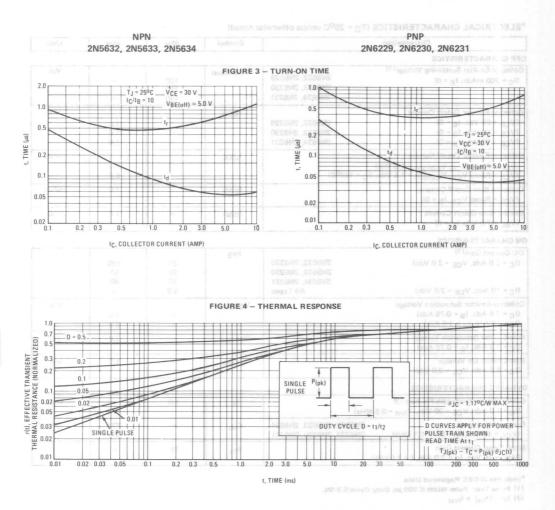
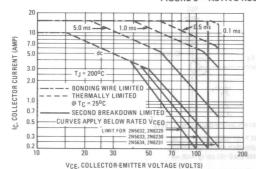


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C = VCE$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate,

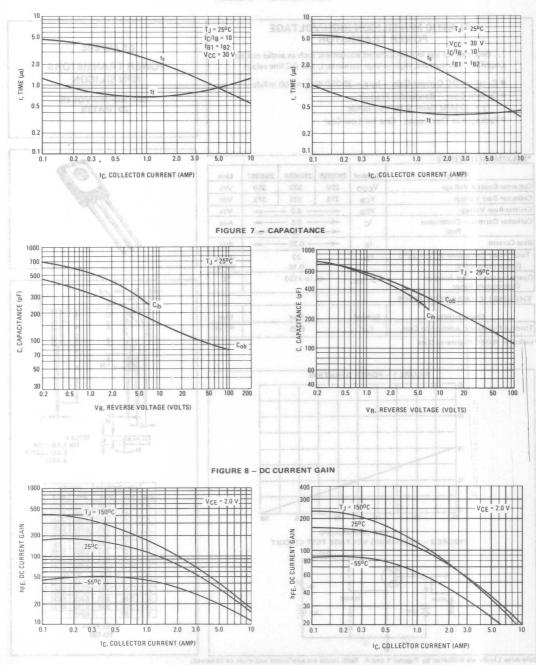
The data of Figure 5 is based on  $T_{J(pk)} = 200$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

NPN 2N5632, 2N5633, 2N5634

PNP 2N6229, 2N6230, 2N6231

2N5655, 2N5656, 2N5657







PIGNOT & THOMOSE TIME

#### PLASTIC NPN SILICON HIGH-VOLTAGE POWER TRANSISTOR

... designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays

- Excellent DC Current Gain hFE = 30-250 @ IC = 100 mAdc
- Current-Gain Bandwidth Product
  - fT = 10 MHz (Min) @ IC = 50 mAdc
- Packaged in Thermopad Case for Low Cost

0.5 AMPERE

2N6632, 2N5633, 2N5634

POWER TRANSISTORS
NPN SILICON

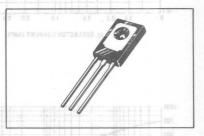
250-300-350 VOLTS 20 WATTS

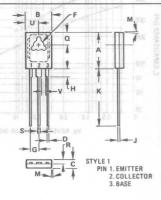
*MAXIMUM RATINGS	0.3 0.5	0.2	0	(8)	0.0
Rating Marsub Rospal	Symbol	2N5655	2N5656	2N5657	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	VCB	275	325	375	Vdc
Emitter-Base Voltage	VEB	-	— 6.0 <b>—</b>	-	Vdc
Collector Current - Continuous Peak	1C	211	- 0.5 - - 1.0 -	1AO T E	Adc
Base Current	I <sub>B</sub>	-	— 0.25 —	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		20 0.16		Watts W/OC
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>		5 to +150		°C

THERMAL	CHARAC	TERISTICS
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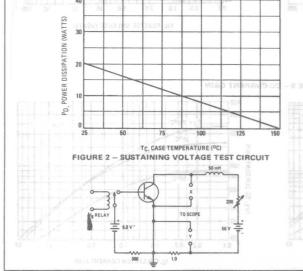
	1 111111		1 197.0
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	6.25	°C/W

FIGURE 1 - POWER DERATING





-	MILLIN	IETERS	INC	HES
MID	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
H	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	0 TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-



Safe Area Limits are indicated by Figures 3 and 4. Both limits are applicable and must be observed,

<sup>\*</sup>Indicates JEDEC Registered Data

Characteristic		Symbol	Min	Max	·Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAdc (inductive), L = 50 mH)	2N5655 2N5656 2N5657	V <sub>CEO(sus)</sub>	250 300 350	=	Vdc
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	2N5655 - 3 5 H 2N5656 2N5657	BVCEO	250 300 350	=	Vdc
Collector Cutoff Current (VCE = 150 Vdc; I <sub>B</sub> = 0) (VCE = 200 Vdc; I <sub>B</sub> = 0) (V <sub>CE</sub> = 250 Vdc; I <sub>B</sub> = 0)	2N5655 2N5656 2N5657	ICEO	-	0.1 0.1 0.1	mAdc
Collector Cutoff Current (VCE = 250 Vdc, VEB(off) = 1.5 Vdc) (VCE = 300 Vdc, VEB(off) = 1.5 Vdc) (VCE = 350 Vdc, VEB(off) = 1.5 Vdc) (VCE = 350 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 100 °C) (VCE = 200 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 100 °C) (VCE = 200 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 100 °C)	2N5655 2N5656 2N5657 2N5655 2N5656 2N5656	ICEX	39001+	0.1 0.1 0.1 1.0 1.0	mAdc
Collector Cutoff Current (VCB = 275 Vdc, IE = 9) (VCB = 325 Vdc, IE = 0) (VCB = 375 Vdc, IE = 0)	2N5655 2N5656 2N5657	ГСВО		10 10 10	μAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, IC = 0)	IC. COLLECTOR CURRENT (n	IEBO	0.3	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I) = 50 mAdc, V <sub>CE</sub> = 10 Vdc) (I) = 100 mAdc, V <sub>CE</sub> = 10 Vdc) (I) = 150 mAdc, V <sub>CE</sub> = 10 Vdc) (I) = 500 mAdc, V <sub>CE</sub> = 10 Vdc)	08c	hFE 838	25 30 15 5.0	250	FIG
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 100 mAdc)	= 00/ \$ 100   3/ 100	VCE(sat)	- 30V 0 89	1.0 2.5 10	Vdc
Base-Emitter Voltage (1)		VRE		1.0	Vdc

(I<sub>C</sub> = 100 mAdc, V<sub>CE</sub> = 10 Vdc, f = 1.0 kHz) \*Indicates JEDEC.Registered Data for 2N5655 Series.

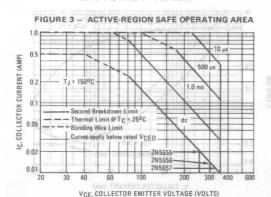
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

(2) f<sub>T</sub> is defined as the frequency at which |h<sub>fe</sub>| extrapolates to unity.

(I<sub>C</sub> = 100 mAdc, V<sub>CE</sub> = 10 Vdc) DYNAMIC CHARACTERISTICS Current-Gain-Bandwidth Product (2)

Small-Signal Current Gain

(IC = 50 mAdc, VCE = 10 Vdc, f = 10 MHz) Output Capacitance (VCB = 10 Vdc, IE = 0, f = 100 kHz)



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

25

10

20

fŢ

Cob

hfe

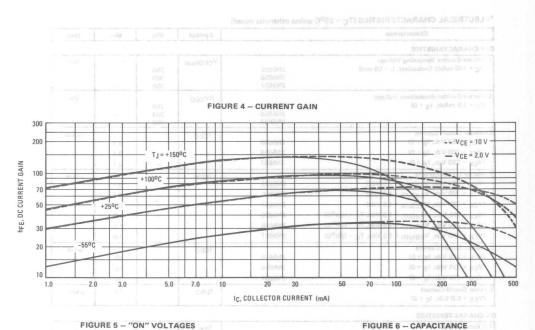
60 100

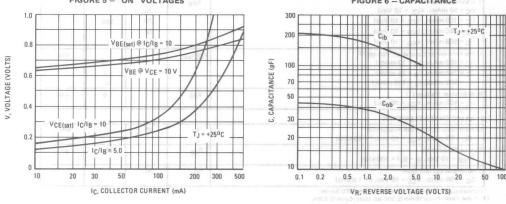
MHz

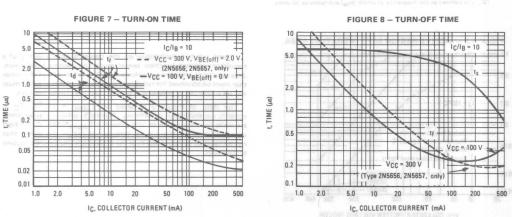
pF

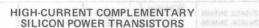
The data of Figure 3 is based on  $T_{J(pk)}=150^{0}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided TJ(pk) \$\leq 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second











. . . designed for use in high-power amplifier and switching circuit applications.

- High Current Capability IC Continuous = 50 Amperes.
- DC Current Gain +
   hFE = 15 60 @ IC = 25 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 25 Adc

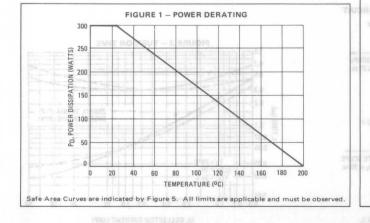
# \*MAXIMUM RATINGS

Rating	Symbol	2N5683 2N5685	2N5684 2N5686	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.	0	Vdc
Collector Current – Continuous	1c	(no) 5	0	Adc
Base Current	IB	1	5	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	P <sub>D</sub>	300 1.715		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	0.584	°C/W

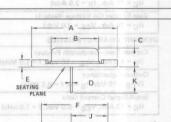
<sup>\*</sup>Indicates JEDEC Registered Data.



#### 50 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS 300 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

G

Н

-	MILLIN	IETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	38.35	39.37	1.510	1.550	
В	19.30	21.08	0.760	0.830	
C	6.35	7.62	0.250	0.300	
D	1.45	1.60	0.057	0.063	
E	-	3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	24.89	26.67	0.980	1.050	

CASE 197-01 TO-3 Except Pin Diameter 3

2N5685, 2N5689 HPN







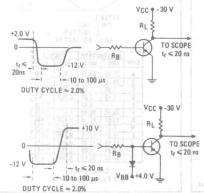
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
FF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (Note 1) (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)		2N5685 2N5686	VCEO(sus)		IUM CURREN	Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0) (VCE = 40 Vdc, IB = 0)		2N5685 2N5686	OBO <sup>1</sup> - Idea of the second se	Igms retvog-d	1.0 girl ni 1.0 not t	mAdc
Collector Cutoff Current (VCE = 60 Vdc, VEB(off) = 1.5 Vdc) (VCE = 80 Vdc, VEB(off) = 1.5 Vdc) (VCE = 60 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C) (VCE = 80 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N5684, 2N5683,		ICEX magmA GB =	nomit#93 31	2.0 - VIII 2.0 00 111 10 10 10 10 11	MAde  High Culture  Dir Culture
Collector Cutoff Current (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)		2N5685 2N5686	ICBO – si		2.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			IEBO	-	5.0	mAdc
ON CHARACTERISTICS			•	•		
DC Current Gain (Note 1) (I <sub>C</sub> = 25 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 50 Adc, V <sub>CE</sub> = 5.0 Vdc)			hFE	15 5.0	60 304	IMUM RATH
Collector-Emitter Saturation Voltage (Note 1) (I C = 25 Adc, I <sub>B</sub> = 2.5 Adc) (I C = 50 Adc, I <sub>B</sub> = 10 Adc)	tinia obV	58201 08	VCE(sat)	Symbol OZOV	1.0	pait::FVdc tor-5ter Vol
Base-Emitter Saturation Voltage (Note 1) (IC = 25 Adc, IB = 2.5 Adc)	Vdc	QB	V <sub>BE</sub> (sat)	V <sub>CB</sub>	2.0	Vdc
Base-Emitter On Voltage (Note 1) (I <sub>C</sub> = 25 Adc, V <sub>CE</sub> = 2.0 Vdc)	Adu		V <sub>BE</sub> (on)	- 0	2.0	tor CabVest - C
DYNAMIC CHARACTERISTICS	Varts	1	DBE	1 3	SORCE AT MAS	Davie: Dissipati
Current-Gain—Bandwidth Product (IC = 5.0 Adc, VCE = 10 Vdc, f = 1.0 MHz)	39\W	-	artf <sub>T</sub>	2.0	noisonut.	O MHz de s
Output Capacitance (VCB = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	2N5683, : 2N5685, :		C <sub>ob</sub>	1 - 1	2000 1200	egne PpF misses
Small-Signal Current Gain (IC = 10 Adc, VCE = 5.0 Vdc, f = 1.0 kHz)			h <sub>fe</sub>	15	ACTERISTICS	RMAL CHAR

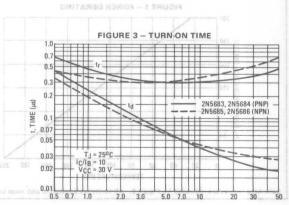
\*Indicates JEDEC Registered Data

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

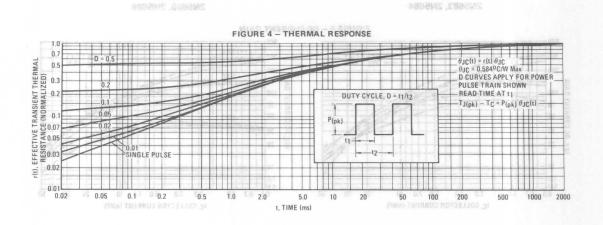
#### FIGURE 2 - SWITCHING TIME TEST CIRCUIT

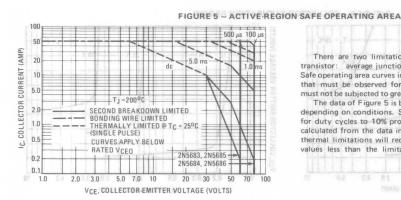


FOR CURVES OF FIGURES 3 & 6, R  $_{\rm B}$  & R  $_{\rm L}$  ARE VARIED. INPUT LEVELS ARE APPROXIMATELY AS SHOWN. FOR NPN CIRCUITS, REVERSE ALL POLARITIES.



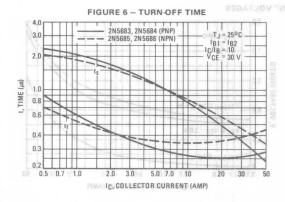
IC, COLLECTOR CURRENT (AMP)

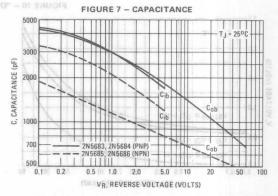




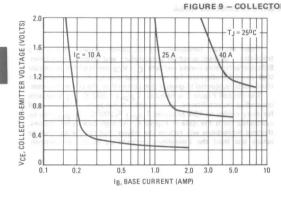
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $|C-V_{CE}|$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

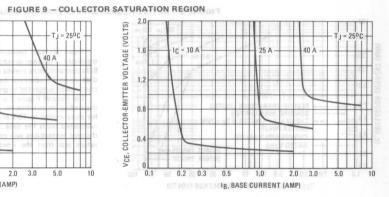
The data of Figure 5 is based on T  $J(pk) = 200^{\circ}C$ ; TC is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided T  $J(pk) \lesssim 200^{\circ}C$ . T J(pk) may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

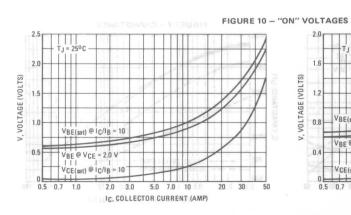


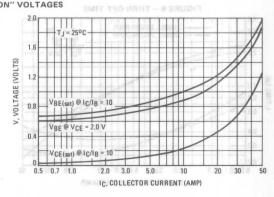












#### HIGH-VOLTAGE HIGH-POWER SILICON TRANSISTORS

 $\dots$  . designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

• High Collector-Emitter Sustaining Voltage -

VCEO(sus) = 100 Vdc (Min) - 2N5758, 2N6226

= 120 Vdc (Min) – 2N5759, 2N6227 = 140 Vdc (Min) – 2N5760, 2N6228

DC Current Gain @ Ic = 3.0 Adc -

hFE = 25 (Min) - 2N5758, 2N6226

= 20 (Min) - 2N5759, 2N6227

= 15 (Min) - 2N5760, 2N6228

 Low Collector-Emitter Saturation Voltage — VCE(sat) = 1.0 Vdc (Max) @ IC = 3.0 Adc 6 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
100-120-140 VOLTS

SOVE I WATTS



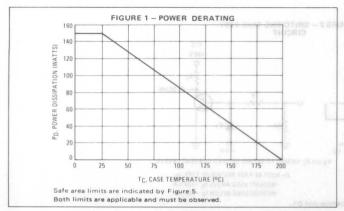
#### \*MAXIMUM BATINGS

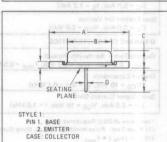
Rating	Symbol	2N5758 2N6226	2N5759 2N6227	2N5760 2N6228	Unit
Collector-Emitter Voltage	VCEO	100	120	140	Vdc
Collector-Base Voltage	V <sub>CB</sub>	100	120	140	Vdc
Emitter-Base Voltage	VEB	-	<del>-</del> 7.0 <del>-</del>	-	Vdc
Collector Current - Continuous Peak	ıc		6.0 10		Adc
Base Current	IB IB	-	_ 4.0 _		Adc
Total Device Dissipation@T <sub>C</sub> = 2 Derate above 25°C	5°C PD		— 150 — — 0.857—		Watts W/OC
Operating and Storage Junction, Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +20	0	°C

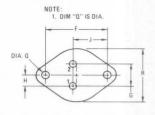
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	θ ЈС	1.17	°C/W	

<sup>\*</sup>Indicates JEDEC Registered Data







	MILLIMETERS		INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	-	39.37	- 2	1.550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	-	3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	-	26.67	-	1.050	

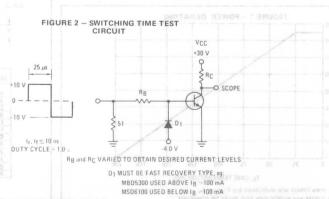
J

		Symbol	Min	Max	Unit	
2N575	59, 2N6227	VCEO(sus)	100 120 140	CH-YOUTA	Vdc	
2N575	59, 2N6227	ICEO III O	T IN ANIGHTS IN	1.0 1.0 1.0	mAdc	rigiri
= 150°C)		OSSENS,			mAdc inh Collector	11.00
		СВО	in) – 2N676i Ado –	W) abV OF =	mAdc	3 0
		IEBO			100	
			0, 2N6228	Not - 2N576	4) 91	
2N57	59, 2N6227	hFE sb/			(CEtsat) =	0
,	overser's	VCE(sat)	-	1.0 2	Vdc DMITAR M	MINA
1130	0.53/7918	V <sub>BE</sub> (on)	symbol 25	1.5	Vdc	B 16th
SHV	140	Linear Contract of the Contrac			ngstho / n	8-1019
Hz) -bA		0.8 fT	1.0	- 200	MHz	0 1070
Adic	-	Cob		300	pF	Carren
Water		081 hfe	15	C-580C	Dove 25°C	
	2N575 2N576 2N576 2N576 2N576 2N576 2N57 2N57 2N57	2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228 All Types	2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228  2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228  ICEO  ICEX  2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228  All Types  VCE(sat)  VBE(on)  fT  Cob	2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228  1CEO  2N5759, 2N6226 2N5759, 2N6227 2N5760, 2N6228  1CEO  1CEO  1CEO  1CEO  1CEX  1CEX  1CES  1CES	2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228    CEO	2N5758, 2N6226 2N5759, 2N6227 2N5760, 2N6228    CEO

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

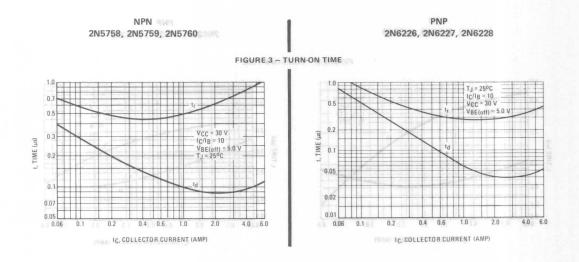
(2) f<sub>T</sub> = |h<sub>fe</sub> | • f test





\*For PNP test circuit, reverse all polarities and D1.





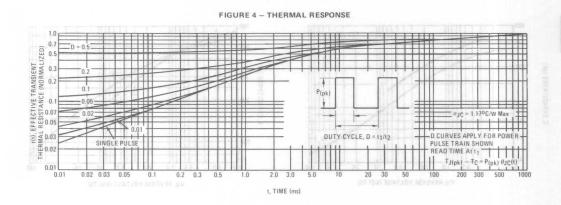
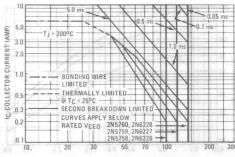


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

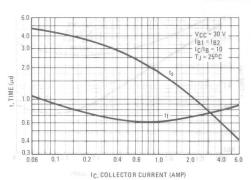
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C-V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate,

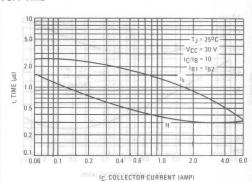
The data of Figure 5 is based on TJ(pk) = 200; TC; is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided TJ(pk)  $\leq 200^{\circ}\text{C}$ . TJ(pk) may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

NPN 2N5758, 2N5759, 2N5760

PNP // // 2N6226, 2N6227, 2N6228

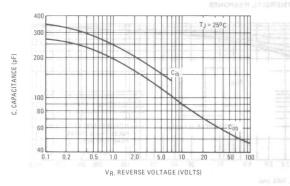
FIGURE 6 - TURN-OFF TIME





#### FIGURE 7 - CAPACITANCE

3



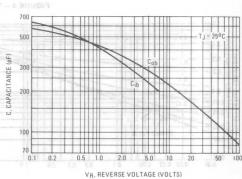
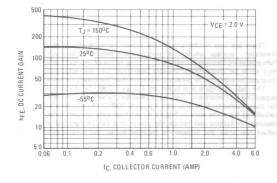
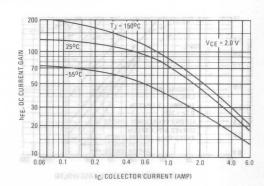


FIGURE 8 - DC CURRENT GAIN







#### HIGH VOLTAGE NPN SILICON POWER TRANSISTORS

. . . designed for high voltage inverters, switching regulators, and lineoperated amplifier applications. Especially well suited for switching power supply applications.

High Collector-Emitter Sustaining Voltage —

VCEO(sus) = 250 Vdc (Min) -

= 275 Vdc (Min) -

= 350 Vdc (Min) -

Excellent DC Current Gain —

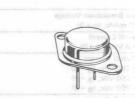
hFE = 10-50 @ IC = 2.0 Adc - 2N5839, 2N5840

= 8-40 @ I<sub>C</sub> = 3.0 Adc - 2N5838



#### NPN SILICON **POWER TRANSISTORS**

250-350 VOLTS 100 WATTS



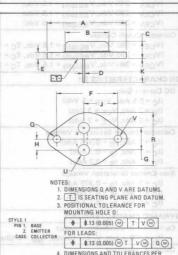
#### \*MAXIMUM RATINGS

Rating ge	Symbol	2N5838	2N5839	2N5840	Unit
Collector-Emitter Voltage	VCEO(sus)	250	275	350	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 50 Ω)	VCER	275	300	375	Vdc
Collector-Emitter Voltage	VCEV	275	300	375	Vdc
Collector-Base Voltage	VCB	275	300	375	Vdc
Emitter-Base Voltage	VEB		6		Vdc
Collector Current — Continuous Peak	IC		3 5		Adc
Base Current	1 <sub>B</sub>		1.5		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	n I	100 0.56		Watts W/OC
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>		-65 to +20	00	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.75	°C/W

\*Indicates JEDEC Registered Data.



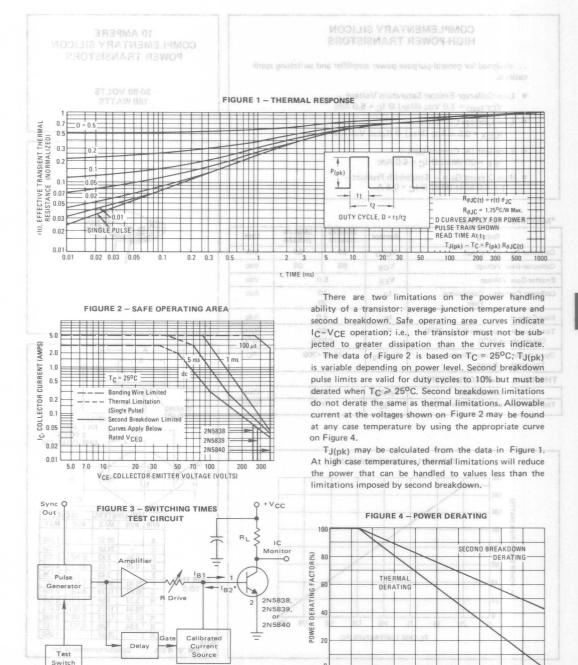
+	Ø.13 (0.005) ₪	TVO	0
FOR	EADS:		111
+	0.13 (0.005) (M) T	V(M)	0 (M)

	MILLIN	MILLIMETERS		HES		
DIM	MIN	MAX	MIN	MAX		
A	NOS III	39.37	342.8Ep -	1.550		
В	SA-3.1	21.08	000.2	0.830		
C	6.35	7.62	0.250	0.300		
D	0.97	1.09	0.038	0.043		
En	1.40	1.78	0.055	0.070		
F	30.15	BSC	1.187 BSC			
G	10.92 BSC		0.430 BSC			
H	5.46	5.46 BSC		0.215 BSC		
J	16.89	BSC	0.665 BSC			
K	11.18	12.19	0.440	0.480		
Q	3.81	4.19	0.150	0.165		
R		26.67	=	1,050		
U	4.83	5.33	0.190	0.210		
V	3.81	4.19	0.150	0.165		



Characteristic			Symbol	Min	Max	Unit
FF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0)	SHOTSK	2N5838 2N5839 2N5840	VCEO(sus)	250 275 350	DLT <u>Ā</u> GĒ	Vdc
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mA, V <sub>BE(off)</sub> = 1.5 V, L = 10 mH)	s, and line- switching	2N5838 2N5839 2N5840	VCEX(sus)	275 300 375	ed forthigh emplifier ap oth amplicat	Defending
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mAdc, R <sub>BE</sub> = 50 Ohms)		2N5838 2N5839 2N5840	VCER(sus)	275 300 375	ollect <del>e</del> r-Emi	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 20 mAdc, I <sub>C</sub> = 0)			V <sub>EBO</sub> —	niM) 6 b V 3	= 27 c 38	Vdc
Emitter Cutoff Current (V <sub>CE</sub> = 6 Vdc, I <sub>C</sub> = 0)			IEBO	nt Gain —	nt DC Curri	mAdc
Collector Cutoff Current ( $VCE = 200 Vdc, I_B = 0$ ) ( $VCE = 250 Vdc, I_B = 0$ ) ( $VCE = 250 Vdc, I_B = 0$ )		2N5838 2N5839 2N5840	ICEO	0 = 340 Ad C = 340 Ad 	2 2	mAdc
Collector Cutoff Current (VCEV = 265 Vdc, VBE(off) = 1.5 Vdc) (VCEV = 290 Vdc, VBE(off) = 1.5 Vdc) (VCEV = 360 Vdc, VBE(off) = 1.5 Vdc)		2N5838 2N5839 2N5840	ICEV	=	5 2 2	mAdc
			ICEV	=	8 5 5	mAdc
N CHARACTERISTICS (1)						
DC Current Gain (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 2 Adc, V <sub>CE</sub> = 3 Vdc)	AL tanu obasil 2N		Hebel 2NS	20	SDIVITA 50 Polite	A NALTARIXA
(I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2 Vdc)	378 V6c	2N5838	SEO (ava) Za	8	40 96V	otri i 3-rotpe
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 0.375 Adc) (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.2 Adc) (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.2 Adc)	375 Vde	2N5838 2N5839 2N5840	VCE(sat)	-	1.0 1.5	off Vdc one Off engage off m3 acros
Base-Emitter Saturation Voltage (I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 0.375 Adc) (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.2 Adc)	25V 618	2N5838 2N5839	V <sub>BE</sub> (sat)		2 000012000 -	Vdc
(I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.2 Adc)	Stati	2N5840			2	- mnuôn
YNAMIC CHARACTERISTICS  Current-Gain—Bandwidth Product  (IC = 200 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 1 Mhz)	Og/An	100 86,0	h <sub>fe</sub>	5	35 6 - 100 38 6 - 100	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f <sub>test</sub> = 1 MHz)	26 00	95 to 428	C <sub>ob</sub>	-	150	pF <sub>qme1</sub>
ECOND BREAKDOWN						
Second Breakdown Collector Current with Base For t = 1.0 s (non-repetitive) (V <sub>CE</sub> = 40 Vdc)	ward Biased		IS/b	2.5	-	Adc
Second Breakdown Energy with Base Reverse Biased ( $I_C = 3.0$ , $V_{BE(off)} = 4.0$ Vdc, $L = 100 \mu H$ )	tioU zahi	t Ladre	E <sub>S/b</sub>	0.45	ARAGTERI Characterist	mJ mJ
NITCHING CHARACTERISTICS, MAXIMUM LIM	ITS WOO at.	31.1	B	easO c	ce, Junetion 16	nujaies Allerm
Resistive Load		Symbol	2N5838(2)	2N5839	2N5840	Unit
Rise Time (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 2 Adc,		t <sub>r</sub>	1.5	1.5	1.75	μs
Storage Time $I_{B1} = I_{B2} = 0.2$ Adc, $t_p = 100 \mu s$ , Duty Cycle $\leq 2\%$	.)	t <sub>S</sub>	3.0	3.75 1.5	3.0 1.5	μs





TC, CASE TEMPERATURE (°C)

\*I<sub>B1</sub> and I<sub>B2</sub> measured with Tektronix current

probe P6019 or equivalent.



## COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

... designed for general-purpose power amplifier and switching applications.

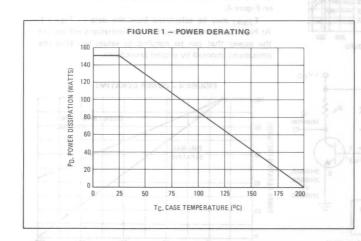
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 5.0 Adc
- Low Leakage Current —
   ICEX = 0.5 mAdc (Max) @ Rated Voltage
- Excellent DC Current Gain —
   hFE = 20 (Min) @ IC = 4.0 Adc
- High Current Gain Bandwidth Product f<sub>T</sub> = 4.0 MHz (Min) @ I<sub>C</sub> = 0.5 A

#### \*MAXIMUM RATINGS

Rating A SMIT GASE	Symbol	2N5875 2N5877	2N5876 2N5878	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current — Continuous Peak	Till I Cawa	10 20		Adc
Base Current	I <sub>B</sub>	4.0		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C		150 0.857		Watts W/ <sup>O</sup> C
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS to not bileve one entirel delate

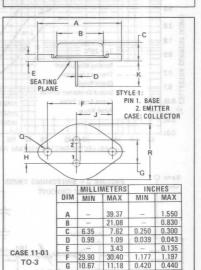
Characteristic Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W



#### 10 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS 150 WATTS





16.64 17.15 0.655 0.675 11.18 12.19 0.440 0.480

Collector connected to case.

1. DIM "Q" IS DIA.

4.09 0.151 0.161 26.67 - 1.050

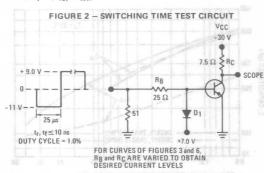
3-140

## 2N5875, 2N5876 PNP, 2N5877, 2N5878 NPN BEIG TREEDS SUB STREETS STREETS SUBSTREETS SUBSTR

\*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

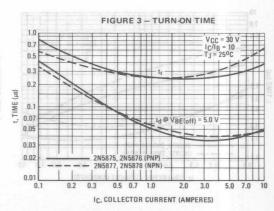
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N5875, 2N5877 2N5876, 2N5878	VCEO(sus)	60 80	_	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N5875, 2N5877 2N5876, 2N5878	ICEO	-	1.0	mAdc
Collector Cutoff Current (VCE = 80 Vdc, VBE(off) = 1.5 Vdc) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 1 (V <sub>C</sub> E = 80 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 1		CEX	- 1	0.5 0.5 5.0 5.0	mAdc
Collector Cutoff Current (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N5875, 2N5877 2N5876, 2N5878	СВО	=	0.5 0.5	mAdc
Emitter Cutoff Current (VEB = 5.0 Vdc, IE = 0)	v III	IEBO	-	1.0	mAdc
ON CHARACTERISTICS					600
DC Current Gain (1) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)	L. Freit: (ma)	hFE	35 20 4.0	100	-
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.5 Adc)	AREA	VCE(sat)	LAZ MOTAS	1.0	Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.5 Adc)	There are two li	V <sub>BE</sub> (sat)	1	2.5	Vdc
Base-Emitter On Voltage (1)	ago savic indizionenti	VBE(on)		1.5	Vdc
DYNAMIC CHARACTERISTICS	fon faum massemi	2 / tm 1 s / Z			
Current-Gain — Bandwidth Product (2) (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MH	curves indicate, The data of E (sh	/ fT	4.0		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz) 2N5875, 2N5876 2N5877, 2N5878		C <sub>ob</sub>	OFFICE DATES & TO TATES & TO TATES & TO	500 300	pF
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, $V_{CE}$ = 4.0 Vdc, f = 1.0 kHz)		h <sub>fe</sub>	20	Baluw Rated V	Augus Augus
SWITCHING CHARACTERISTICS	ent	10 70	20 30	81	0 1
Rise Time		(81 <sub>tr</sub> (81)	TON FREE TANK	0.7	μs
Storage Time (V <sub>CC</sub> = 30 Vdc, I <sub>C</sub>	= 4.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.4 Adc,	ts	-	1.0	μs
Fall Time See Figure 2)		tf	_	0.8	μs

<sup>\*</sup>Indicates JEDEC Registered Data.



For NPN test circuit, reverse all polarities.

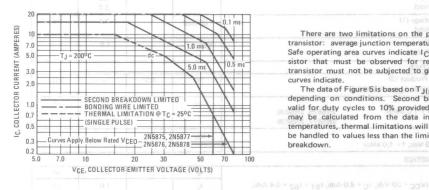
D1 MUST BE FAST RECOVERY TYPE, e.g. MBD5300 USED ABOVE IB  $\approx$  100 mA MSD6100 USED BELOW IB  $\approx$  100 mA



PIGURE 6 - TURN OFF TIME

 <sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
 (2) f<sub>T</sub> = |h<sub>fe</sub>| • f<sub>test</sub>

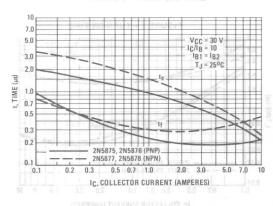
#### FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA



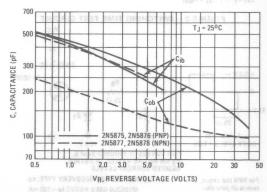
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown, Safe operating area curves indicate I<sub>C</sub> - V<sub>CE</sub> limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### FIGURE 6 - TURN-OFF TIME



#### FIGURE 7 - CAPACITANCE



# MOTOROLA

#### COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

. designed for general-purpose power amplifier and switching applications.

- Collector-Emitter Sustaining Voltage VCEO(sus) = 60 Vdc (Min) - 2N5879, 2N5881 = 80 Vdc (Min) - 2N5880, 2N5882
- DC Current Gain —

hFE = 20 (Min) @ IC = 6.0 Adc

- Low Collector Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 7.0 Adc
- High Current Gain-Bandwidth Product fT = 4.0 MHz (Min) @ IC = 1.0 Adc
- Recommended for New Circuit Designs

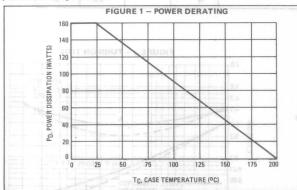
#### \*MAXIMUM RATINGS

Rating	Symbol	2N5879 2N5881	2N5880 2N5882	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current — Continuous Peak	C(no)		15 30	Adc
Base Current	IB	5	.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	160 0.915		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		o +200	°С

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	1.1	°C/W

\*Indicates JEDEC registered data. Limits and conditions differ on some parameters and re registration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.



### 15 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS 160 WATTS



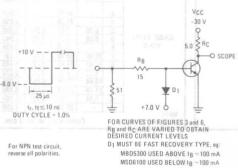
- B -0-00 STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR

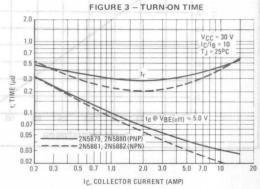
	TOTAL	MILLI	METERS	INC	HES
	DIM	MIN	MAX	MIN	MAX
	A	_	39.37	_	1.550
	В	-	21.08	-	0.830
	C	6.35	7.62	0.250	0.300
CASE 11-01	D	0.99	1.09	0.039	0.043
TO-3	E	-	3.43	-	0.135
	F	29.90	30.40	1.177	1.197
	G	10.67	11.18	0.420	0.440
	H	5.33	5.59	0.210	0.220
	J	16.64	17.15	0.655	0.675
	K	11.18	12.19	0.440	0.480
	0	3.84	4.09	0.151	0.161
Q-X 824	R	-	26.67	(1 <sub>0</sub> ,1)	1.050
IOTE:		-		JOYDY	TUG

Collector connected to case.

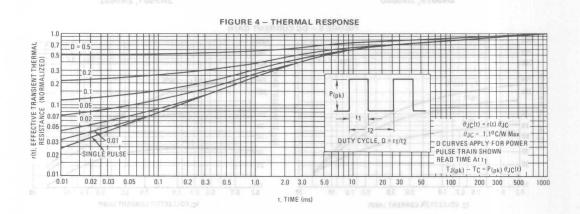
## \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

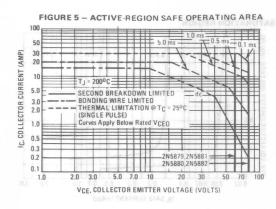
	Characteristic			Symbol	Min	Max	Unit
OFF CHARACTER							
(I <sub>C</sub> = 200 mAdc	Sustaining Voltage (1)		2N5879, 2N5881 2N5880, 2N5882	VCEO(sus)	60 80	COMP	Vdc
	urrent 1/13 19(400) 1 <sub>B</sub> = 0) 93 W09		2N5879, 2N5881	ICEO	-	1.0	mAdc
(V <sub>CE</sub> = 40 Vdc,	I <sub>B</sub> = 0)		2N5880, 2N5882	ris tswog	engreq-lar	1.0	ingi seti
Collector Cutoff C (V <sub>CE</sub> = 60 Vdc,	VBE(off) = 1.5 Vdc)		2N5879, 2N5881	ICEX	BoV aminia	0.5	mAdc
(V <sub>CE</sub> = 80 Vdc,	V <sub>BE(off)</sub> = 1.5 Vdc)		2N5880, 2N5882		IS - HIMI		
(V <sub>CE</sub> = 60 Vdc,	VBE(off) = 1.5 Vdc, TC = 15000	2)	2N5879, 2N5881	15880, 2NS	(Min <del>s)</del> - 28		
('YCE = 80 Vdc,	VBE (off) = 1.5 Vdc, TC = 15000	2)	2N5880, 2N5882		_	5.0	nerson art
Collector Cutoff C (V <sub>CB</sub> = 60 Vdc,			2N5879, 2N5881	ІСВО	= 6.0 Ade	0.5	mAdc
(V <sub>CB</sub> = 80 Vdc,			2N5880, 2N5882	on Voltage	ter Saturati	0.5	Lc - Colle
Emitter Cutoff Cu (VEB = 5.0 Vdc,	rrent			IEBO	dibiwass	1.0	mAdc
ON CHARACTERIS				plak	10.1-014	Hay (Min)	Ina -t
DC Current Gain (				hFE	G tiubat3 w	reld tot bishi	paymic suffici
(I <sub>C</sub> = 2.0 Adc, V				"FE	35		
(I <sub>C</sub> = 6.0 Adc, V (I <sub>C</sub> = 15 Adc, V	CE = 4.0 Vdc)				20	100	FAR F JM
	Saturation Voltage (1)	Hall	5801 2NS082	VCE(sat)		1.0	Vdc Vdc
(I <sub>C</sub> = 15 Adc, I <sub>B</sub>				040	_	4.0	of wather dead
Base-Emitter Satur		Vde	08 08	V <sub>BE</sub> (sat)	-	2.5	Vdc
Base-Emitter On V	'oltage (1)	ShA	87 30	V <sub>BE</sub> (on)	1-	1.5	Vdc
OYNAMIC CHARA		Ade	9.8	51		2102.7	1 :000
	dwidth Product (2)  CE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	Wates	097 81830	fr a	4.0	ion@rc=a	MHz
Output Capacitano		2 <sup>ct</sup>	305+ 61 59-	Cob		nonunel se	pF and
$(V_{CB} = 10 \text{ Vdc},$	I <sub>E</sub> = 0, f = 100 kHz)		2N5879, 2N5880		-	600	muliti shon shope
SII SiI S			2N5881, 2N5882		-	400	
Small-Signal Current (IC = 2.0 Adc, V	CE = 4.0 Vdc, f = 1.0 kHz)			h <sub>fe</sub>	20	ACTERIS	BANG-JAN
SWITCHING CHAR	ACTERISTICS	2100	ROW	Symbut		9010	970 N 1677
Rise Time	(Vac = 20 Vdc 1 0 0	A do		t <sub>r</sub>	_ + *****	0.7	μs
Storage Time	(V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 6.0			t <sub>S</sub>	pore shirt at	1.0	μs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 0.6 Adc See	rigure 2)		tf	-	0.8	μs
ndicates JEDEC Re	igistered Data. Width≤ 300 μs, Duty Cycle≤ 2.0	0%	8	TEAD IO NO	WD4 - 79A	COIN I	031
FIGURE 2 -	SWITCHING TIMES TEST C	IRCUIT		F	IGURE 3 -	TURN-ON	TIME
	V <sub>0</sub>	20	2.0		DHI T		
		0 V					VCC = 30 V
	SOUTH CONSTITUTE OF THE	?	0.7				I <sub>C</sub> /I <sub>B</sub> = 10 T <sub>J</sub> = 25°C
10 V >	5.0	S HC	0.5				





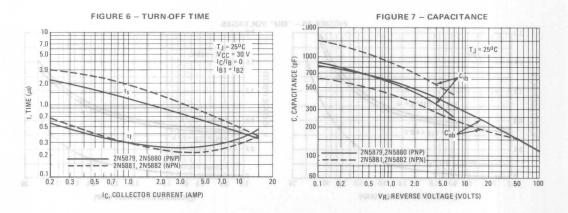
AJOROTOR





There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\hbox{\scriptsize C}}-V_{\hbox{\scriptsize CE}}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

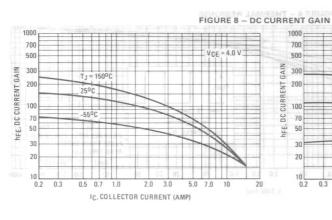
The data of Figure 5 is based on  $T_{J(pk)}=200^{\circ}C;\,T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^{\circ}C,\,T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

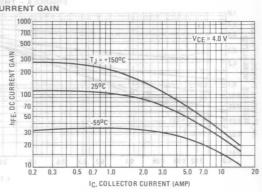


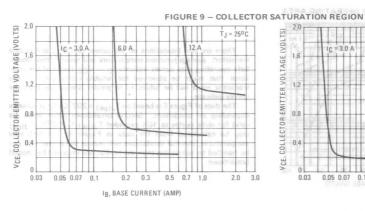
3

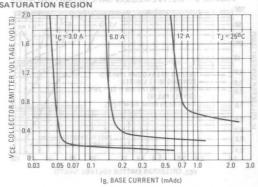


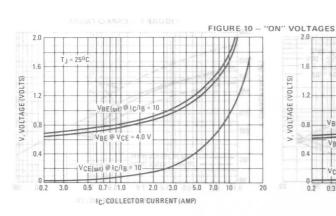
NPN 2N5881, 2N5882

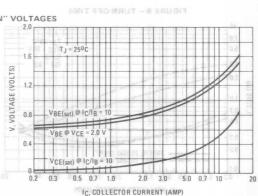












# ob (sus)OROV

HIGH-POWER TRANSISTORS
. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc, (max) at IC = 15 Adc
- Low Leakage Current
   ICEX = 1.0 mAdc (max) at Rated Voltage
- Excellent DC Current Gain —
   hFE = 20 (min) at IC = 10 Adc
- High Current Gain Bandwidth Product –
   f<sub>T</sub> = 4.0 MHz (min) at I<sub>C</sub> = 1.0 Adc

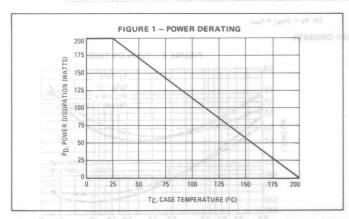
#### \*MAXIMUM RATINGS

Rating	Symbol	2N5883 2N5885	2N5884 2N5886	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	v <sub>CB</sub>	60	80	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current — Continuous Peak	¹c	1 -	25 60	Adc
Base Current	1 <sub>B</sub>	7	.5	Adc
Total Device Dissipation @ T <sub>C</sub> = 25 Derate above 25 <sup>o</sup> C	°C PD		00 .15	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 t	o +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	0.875	°C/W

<sup>\*</sup>Indicates JEDEC registered data. Limits and conditions differ on some parameters and reregistration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.



# 25 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

(0°081 + 5T .88 / 60-80 VOLTS 6 / 68 + 30 VI



12.00	MILLIMETERS		INCHES		
DIM	MIN	MAX	MIN	MAX	
A	- B	39.37	_	1.550	
В	-	21.08		0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	-	3.43	- 1	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R		26.67	0187	1.050	

NOTE: Collector connected to case
1. DIM "Q" IS DIA. CASE 11-01
TO-3

3

2N5883, 2N5884 PNP, 2N5885, 2N5886 NPN

#### Symbol Min Max Characteristic OFF CHARACTERISTICS Collector-Emitter Sustaining Voltage (1) VCEO(sus) Vdc 2N5883, 2N5885 60 (I<sub>C</sub> = 200 mAdc, I<sub>B</sub> = 0) 2N5884, 2N5886 80 mAdo Collector Cutoff Current ICEO 2.0 2N5883, 2N5885 (V<sub>CE</sub> = 30 Vdc, I<sub>B</sub> = 0) (VCE = 40 Vdc, IB = 0) 2N5884, 2N5886 2.0 Collector Cutoff Current mAdc ICEX (V<sub>CE</sub> = 60 Vdc, V<sub>BE(off)</sub> = 1.5 Vdc) 2N5883, 2N5885 1.0 1.0 (VCE = 80 Vdc, VBE (off) = 1.5 Vdc) 2N5884, 2N5886 (V<sub>CE</sub> = 60 Vdc, V<sub>BE(off)</sub> = 1.5 Vdc, T<sub>C</sub> = 150°C) 2N5883, 2N5885 10 of at to (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) 2N5884, 2N5886 10 Collector Cutoff Current mAdc CBO 1.0 2N5883, 2N5885 $(V_{CB} = 60 \text{ Vdc}, I_{E} = 0)$ (V<sub>CB</sub> = 80 Vdc, I<sub>E</sub> = 0) 2N5884, 2N5886 1.0 Emitter Cutoff Current 1.0 mAdc IEBO $(V_{EB} = 5.0 \text{ Vdc}, I_{C} = 0)$ ON CHARACTERISTICS DC Current Gain (1) hFE (IC = 3.0 Adc, VCE = 4.0 Vdc) 35 (IC = 10 Adc, VCE = 4.0 Vdc) 20 100 4.0 (IC = 25 Adc, VCE = 4.0 Vdc) Collector-Emitter Saturation Voltage (1) Vdc VCE (sat) 1.0 (IC = 15 Adc, IB = 1.5 Adc) (IC = 25 Adc, IB = 6.25 Adc) 4.0 Base-Emitter Saturation Voltage (1) VBE (sat) 2.5 Vdc (IC = 25 Adc, IB = 6.25 Adc) Base-Emitter On Voltage (1) 1.5 Vdc VBE(on) (IC = 10 Adc, VCE = 4.0 Vdc) DYNAMIC CHARACTERISTICS Current-Gain-Bandwidth Product (2) 4.0 MHz (IC = 1.0 Adc, VCE = 10 Vdc, ftest = 1.0 MHz) Output Capacitance Cob pF (V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f = 1.0 MHz) 2N5883, 2N5884 1000 2N5885, 2N5886 500 Small-Signal Current Gain 20 hfe (IC = 3.0 Adc, VCE = 4.0 Vdc, ftest = 1.0 kHz) SWITCHING CHARACTERISTICS Rise Time 0.7 (VCC = 30 Vdc, IC = 10 Adc, Storage Time ts 10 US IB1 = IB2 = 1.0 Adc) Fall Time 0.8 \*Indicates JEDEC Registered Data: (1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%. (2) f<sub>T</sub> = |h<sub>fe</sub>| • f<sub>test</sub> FIGURE 2 - SWITCHING TIME EQUIVALENT TEST CIRCUITS TURN-ON TIME VCC 9 -30 V FIGURE 3 - TURN-ON TIME ≥ 3.0 T<sub>J</sub> = 25°C +2.0 V IC/IB = 10 TO SCOPE VCC = 30 V 0.7 VRF(off) -11.0 V 0.5 - 10 to 100 μs (srt) 0.3 DUTY CYCLE ≈ 2.0% TIME ( 0.2 TURN-OFF TIME VCC ♥ -30 V 2N5883, 2N5884 (PNP) 0.1 RL ≥ 3.0 2N5885, 2N5886 (NPN) 0.07 +9.0 V TO SCOPE 0.05 RB $t_{\Gamma} \le 20 \text{ ns}$

FOR CURVES OF FIGURES 3 & 6, RB & RL ARE VARIED. INPUT LEVELS ARE APPROXIMATELY AS SHOWN. FOR NPN, REVERSE ALL POLARITIES

VBB +7.0 V

 $-t_{\Gamma} \le 20 \text{ ns}$ 

- 10 to 100 μs

DUTY CYCLE ≈ 2.0%

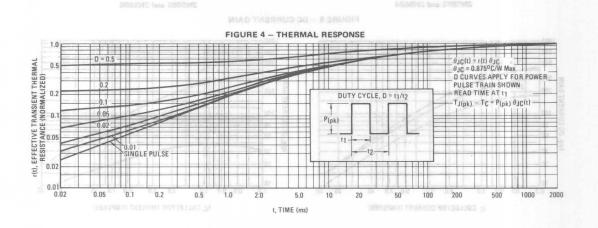
-11 0 V

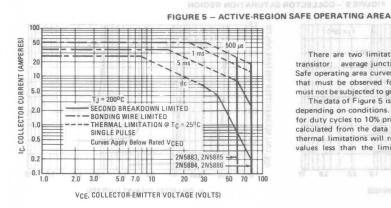
0.03

0.02

5.0 7.0

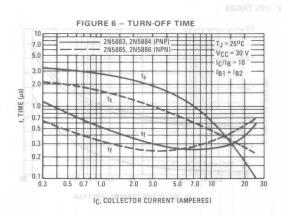
IC, COLLECTOR CURRENT (AMPERES)

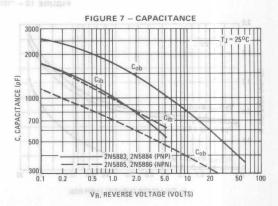




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on  $T_{J(pk)}=200^{\circ}C; T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

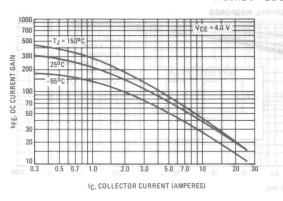


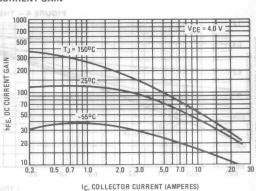




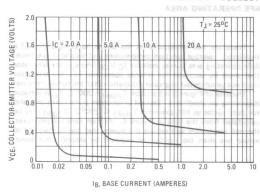
#### NPN DEVICES 2N5885 and 2N5886

#### FIGURE 8 - DC CURRENT GAIN





#### FIGURE 9 - COLLECTOR SATURATION REGION



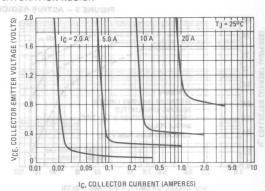
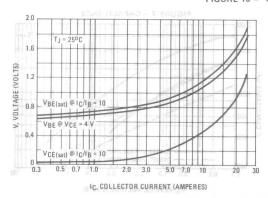
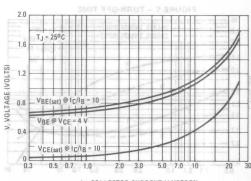


FIGURE 10 - "ON" VOLTAGES





IC, COLLECTOR CURRENT (AMPERES)

\*ELECTRICAL CHARACTERISTICS (To = 25°C univer extrem



#### PNP SILICON PLASTIC POWER TRANSISTORS

. . . designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 5 Amperes hFE = 20-120 @ IC = 2.5 Adc = 7.0 (Min) @ I<sub>C</sub> = 5.0 Adc
- Collector-Emitter Sustaining Voltage VCEO(sus) = 40 Vdc (Min) - 2N5974 = 60 Vdc (Min) - 2N5975 = 80 Vdc (Min) - 2N5976
- High Current Gain Bandwidth Product fT = 2.0 MHz (Min) @ IC = 500 mAdc
- Complements to NPN Transistors 2N5977, 2N5978, 2N5979

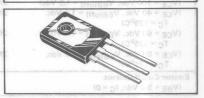
#### 5 AMPERE POWER TRANSISTORS

Collector-Emitter Sustaining Voltage (1)

PNP SILICON

40-60-80 VOLTS Voe + 80 Voe STTAW 75 15 Voe

(VCE = 80 V



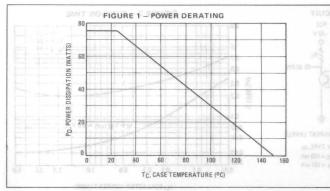
#### \*MAXIMUM RATINGS

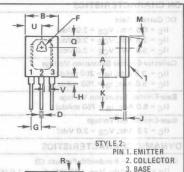
Rating	Symbol	2N5974	2N5975	2N5976	Unit
Collector-Emitter Voltage	VCEO	40	(1600V	80	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	-	- 5.0 -	-	Vdc
Collector Current - Continuous Peak	Ic	=	5.0 10	-	Adc
Base Current	IB	-	2.0	-	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD		75 — — 0.60 —		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	2:0	-65 to +150	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	1.67	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data for 2N5974 Series





#### NOTES:

- 1. DIM "D" UNCONTROLLED IN ZONE "H"
  2. DIM "F" DIA THRU
  3. HEAT SINK CONTACT AREA (BOTTOM)

  - 4. LEADS WITHIN 0.005" RAD OF TRUE
    POSITION (TP) AT MAXIMUM MATERIAL

MIT I	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	16.13	16.38	0.635	0.645
В	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22	2 BSC	0.16	6 BSC
Н	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90	TYP	90	TYP
0	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
V	2.03	-	0.080	-

**CASE 90-05** TO-127

### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

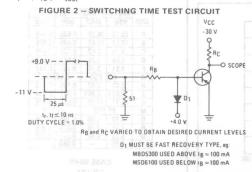
Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) $(I_C = 100 \text{ mAdc}, I_B = 0)$	2N5974 2N5975 2N5976	2000	VCEO(sus)	40 60 80	- de serves de	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N5974 2N5975 2N5976	gairdring t	ICEO	grug (sechog	1.0 bengi 1.0 .200 1.0	mAdc esb iss ilqqs
Collector Cutoff Current (VCE = 60 Vdc, VEB(off) = 1.5 Vdc) (VCE = 80 Vdc, VEB(off) = 1.5 Vdc) (VCE = 100 Vdc, VEB(off) = 1.5 Vdc)	2N5974 2N5975 2N5976		CEX	= 2.5. <u>A</u> dc	100 100	
(V <sub>CE</sub> = 40 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (V <sub>CE</sub> = 60 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (V <sub>CE</sub> = 80 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	2N5974 2N5975 2N5976				1.0	ev.
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		NEB78	ST. SEBO TTO	ransis <u>t</u> ors 2018	MSM of Dicerrola	mAdc
ON CHARACTERISTICS	-					
DC Current Gain (IC = 0.5 Adc, VCE = 2.0 Vdc) (IC = 2.5 Adc, VCE = 2.0 Vdc) (IC = 5.0 Adc, VCE = 2.0 Vdc)	finti	DYNAS	hFE	40 20 7.0	120	R HUMXAM
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 250 mAdc)	Vrte	(5)	VCE (sat)	(c) 46	0.6	et in Vdc sillo
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 750 mAdc)  Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 750 mAdc)	Vac		V <sub>BE</sub> (sat)	193	1.7	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	5/19/4		VBE(on)		1.4	Vdc
DYNAMIC CHARACTERISTICS	stratil			0	noties,	Other Power Diet

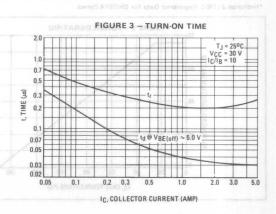
## DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product (2)	of To		3°es	MHz
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	100 to ot 650	2.0	F northoot spend	
Output Capacitance	Cob		98/10/3	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)		-	300	
Small-Signal Current Gain	h <sub>fe</sub>	8	ARACTERISTIC	HERMAI CH
(I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 kHz)	veld Lesfaiv2	20	Chargerspiede	

<sup>\*</sup>Indicates JEDEC Registered Data

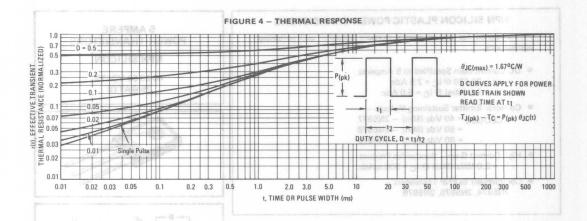
<sup>(2)</sup> f<sub>T</sub> = | h<sub>fe</sub> | • f<sub>test</sub>

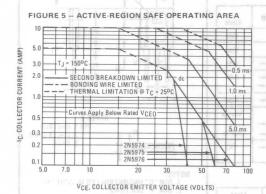




<sup>(1)</sup> Pulse Test: Pulse Width≤300 µs, Duty Cycle≤2.0%.

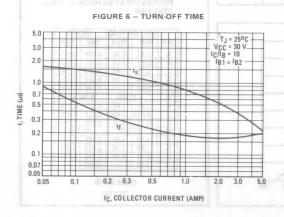
MOTOROLA

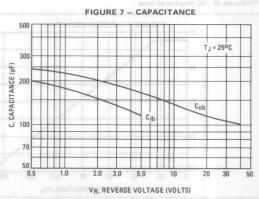




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor

Sate operating area curves indicate  $I_C$ -VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on  $T_J(p_K) = 150^{\rm O}$ C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(p_K) \leqslant 150^{\rm O}$ C.  $T_J(p_K)$  may be calculated from the data in Figure 4A. calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.







#### NPN SILICON PLASTIC POWER TRANSISTORS

. . . designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 5 Amperes HE = 20-120 @ IC = 2.5 Adc = 7.0 (Min) @ IC = 5.0 Adc
  - Collector-Emitter Sustaining Voltage -VCEO(sus) = 40 Vdc (Min) - 2N5977 = 60 Vdc (Min) - 2N5978
  - = 80 Vdc (Min) 2N5979 • High Current Gain - Bandwidth Product fT = 2.0 MHz (Min) @ IC = 500 mAdc
  - Complement to PNP Transistors 2N5974, 2N5975, 2N5976

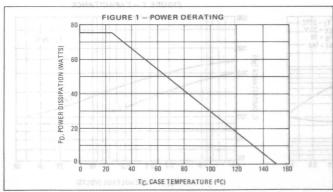
#### \*MAXIMUM RATINGS

Rating	Symbol	2N5977	2N5978	2N5979	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltages bris 910	VEB	tal anni age	5.0	007	Vdc
Collector Current - Continuous Peak	lc	ng Lewised ng Lewised erus as beros	5.0 — 10 —	105	Adc
Base Current T DOOR = (plg)	1 <sub>B</sub>	ria il ampli	2.0	-	Adc
Total Power Dissipation  © T <sub>C</sub> = 25°C  Derate above 25°C	PDeb		75 — 0.60 —		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	the limitor	-65 to +150	lav	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.67	°C/W

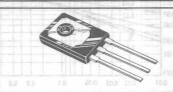
<sup>\*</sup>Indicates JEDEC Registered Data

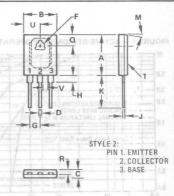


## **5 AMPERE POWER TRANSISTORS**

NPN SILICON

40-60-80 VOLTS 75 WATTS





- OTES:

  1. DIM "D" UNCONTROLLED IN ZONE "H"

  2. DIM "F" DIA THRU

  3. HEAT SINK CONTACT AREA (BOTTOM)

  4. LEADS WITHIN 0.005" RAD OF TRUE

  POSITION (TP) AT MAXIMUM MATERIAL

  CONDITION CONDITION.

TI	MILLIN	ETERS	INC	INCHES		
MID	MIN	MAX	MIN	MAX		
A	16.13	16.38	0.635	0.645		
В	12.57	12.83	0.495	0.505		
C	3.18	3.43	0.125	0.135		
D	1.09	1.24	0.043	0.049		
F	3.51	3.76	0.138	0.148		
G	4.27	BSC	0.166 BSC			
Н	2.67	2.92	0.105	0.115		
J	0.813	0.864	0.032	0.034		
K	15.11	16.38	0.595	0.645		
M	90	TYP	9º TYP			
0	4.70	4.95	0.185	0.195		
R	1.91	2.16	0.075	0.085		
U	6.22	6.48	0.245	0.255		
V	2.03	-	0.080	11-		

CASE 90-05 TINA THERE US AD 133 TO-127

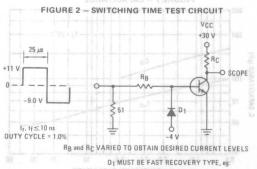
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N5977 2N5978 2N5979	VCEO(sus)	40 60 80	- 1101-11	Vdc
Collector Cutoff Current	2110070	lone	30		mAdo
(V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N5977 2N5978 2N5979	ICEO		1.0 1.0 1.0	MAGC
Collector Cutoff Current (VCE = 80 Vdc, VEB(off) = 1.5 Vdc) (VCE = 80 Vdc, VEB(off) = 1.5 Vdc) (VCE = 100 Vdc, VEB(off) = 1.5 Vdc) (VCE = 40 Vdc, VEB(off) = 1.5 Vdc, TC = 125°C)	2N5977 2N5978 2N5979 2N5977	ICEX		100 100 100 1,0	µAdc mAdc
(V <sub>CE</sub> = 60 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (V <sub>CE</sub> = 80 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	2N5978 2N5979			1.0	10.0
Emitter Cutoff Current 68 68 68 (VBE = 5.0 Vdc, IC = 0)	8 8.8 8.8 8 18 PQLSE WIDTH (ms)	IEBO 2.0	2.0 5.0	1.0	mAdd
DC Current Gain (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	ON SAFE OPERATING	PEE PEG	40 20 7.0	120	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 250 mAdc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 750 mAdc)	There are two,	VCE (sat)		0.6 1.7	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 750 mAdc)	Safe operating area	V <sub>BE</sub> (sat)	4.7	2.5 OUXA3	Vdc
	must not be subjecte The data of Figu	VBE(on)	7/498	CATHEL SHE TATHER 1.4	Vdc
	depending on condi	HERE	73-1	Dates Rand Vese	utes & say
Current Gain — Bandwidth Product (2) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0	calculated from the	fT	2.0		MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)		Cob		200	pF

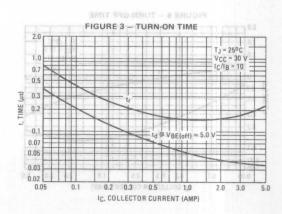
\*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%.

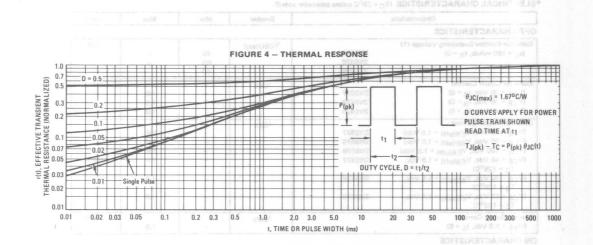
(2) f<sub>T</sub> = | h<sub>fe</sub> | • f<sub>test</sub>



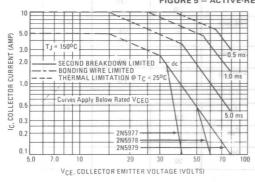
D<sub>1</sub> MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I<sub>B</sub> ≈100 mA
MSD6100 USED BELOW I<sub>B</sub> ≈100 mA





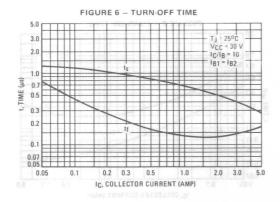


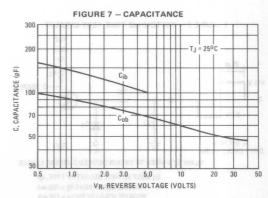
#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C\text{-VCE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}$  =  $150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}$   $\leqslant 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, the temperature  $T_{J(pk)}$  is the power that can be handled to values less than the limitations imposed by second breakdown.





## HIGH POWER PLASTIC COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for use in general-purpose amplifier and switching circuits.

- Collector-Base Voltage V<sub>CBO</sub> = 60 Vdc 2N5986, 2N5989 = 80 Vdc - 2N5987, 2N5990 = 100 Vdc - 2N5988, 2N5991
- Collector-Emitter Voltage VCEO = 40 Vdc 2N5986, 2N5989 = 60 Vdc - 2N5987, 2N5990 = 80 Vdc - 2N5988, 2N5991
- DC Current Gain hFE = 20-120 @ IC = 6.0 Adc = 7.0 (Min) @ IC = 12 Adc
- Collector-Emitter Saturation Voltage VCE(sat) = 0.7 Vdc (Max) @ IC = 6.0 Adc

#### 12 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

> 40, 60, 80 VOLTS 100 WATTS



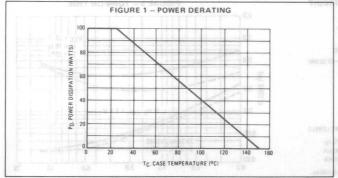
#### \*MAXIMUM RATINGS

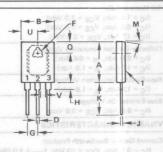
Rating 80	Symbol	2N5986 2N5989	2N5987 2N5990	2N5988 2N5991	Unit
Collector-Base Voltage	VCB	60	80	100	Vdc
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Emitter-Base Voltage	VEB	(mo) 35V 5.0			Vdc
Collector Current — Continuous Peak	lc	12 20		Adc	
Base Current	1 <sub>B</sub>	4.0			Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	0.5 PD	100			Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150			°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.25	°C/W

\*Indicates JEDEC Registered Data





PIN 1. EMITTER 2. COLLECTOR

- DIM "D" UNCONTROLLED IN ZONE "H".
  DIM "F" DIA THRU
- HEAT SINK CONTACT AREA (BOTTOM) 4. LEADS WITHIN 0.005" RAD OF TRUE POSITION (TP) AT MAXIMUM MATERIAL CONDITION.

	MILLIN	METERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
Α	16.13	16.38	0.635	0.645
В	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22	2 BSC	0.16	6 BSC
Н	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90	TYP	90	TYP
0	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
٧	2.03	M SE	0.080	-

**CASE 90-05** 





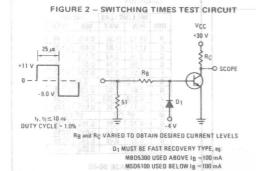
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

2N5989, 2N5990, 2N5991 NPN

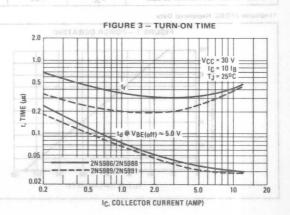
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)	2N5986, 2N5989 2N5987, 2N5990 2N5988, 2N5991	BVCEO(sus)	40 60 80	HIG EMEI <u>V</u> TARY -	Vdc J9MOO
Collector Cutoff Current (V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N5986, 2N5989 2N5987, 2N5990 2N5988, 2N5991	030 <sup>1</sup> 0 Vac — 2N59 0 Vac — 2N59		2.0 2.0 2.0 2.0 2.8 3 40 2.0	mAdc
Collector Cutoff Current (VCE = 60 Vdc, VBE(off) = 1.5 Vdc) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc) (VCE = 40 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (VCE = 60 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (V <sub>CE</sub> = 80 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	2N5986, 2N5989 2N5987, 2N5990 2N5988, 2N5991 2N5986, 2N5989 2N5987, 2N5990 2N5988, 2N5991	* 40 Vac - 2M * 80 Vac - 2M * 80 Vac - 2M	030 <u>V</u> – suc	200 200 2.0	μAdc  Collecte  mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO	C = 12 Adc	(n(nt) 0.7 =	mAdc
ON CHARACTERISTICS			spatio V notice	or Ernikter Setu	orosim Die
DC Current Gain (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 6.0 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 12 Adc, V <sub>CE</sub> = 2.0 Vdc)		hFE	40 20 7.0	- 120	PD V WHA
Collector-Emitter Saturation Voltage (IC = 6.0 Adc, IB = 0.6 Adc) (IC = 12 Adc, IB = 1.8 Adc)	780 21/25931 Unit	VCE (sat)	lodmy?	0.6 gnitst	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 1.8 Adc)	56V 08 (	V <sub>BE</sub> (sat)	OBOV _	2.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 6.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	56V 0	VBE(on)	aav .	1.4 man	oloV Vdc
DYNAMIC CHARACTERISTICS	(	YS .		Pople	
Current-Gain — Bandwidth Product (IC = 0.5 Adc, VCE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	0 Ade	f <sub>T</sub>	91 2.0	etion 6-1 <sub>C</sub> = 26	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	2N5986 thru 2N5988 2N5989 thru 2N5991	0 C <sub>ob</sub>	MET LT	500 300	ord bins grids
Small-Signal Current Gain (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 kHz)		h <sub>fe</sub>	20	ARACTERIST	ERINIL CH

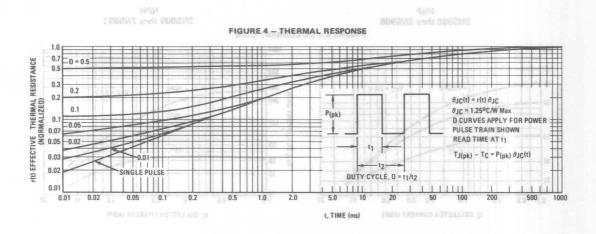
\*Indicates JEDEC Registered Data.

(1) f<sub>T</sub> = |h<sub>fe</sub>| • f<sub>test</sub>

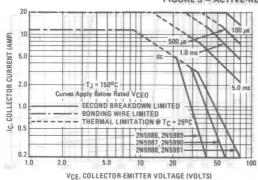


For PNP test circuit reverse diode and voltage polarities.



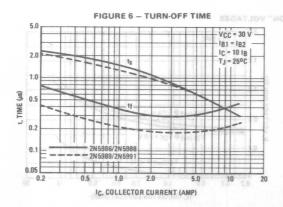


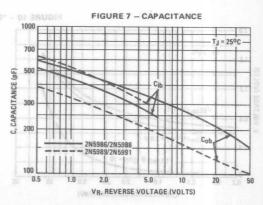


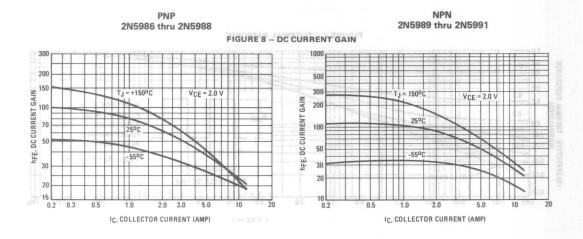


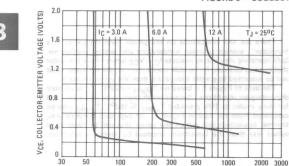
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> – V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

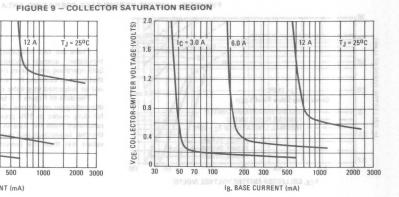
The data of Figure 5 is based on  $T_J(pk) = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \le 150^{\circ}C$   $T_J(pk)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

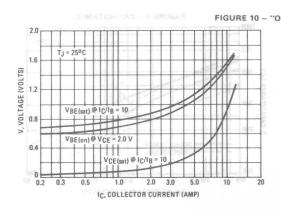




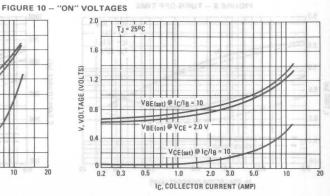








IB, BASE CURRENT (mA)





# 2N6034, 2N6035, 2N6036 PNP 2N6037, 2N6038, 2N6039 NPN

## PLASTIC DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

 $\ldots$  , designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain
  - hFE = 2000 (Typ) @ IC = 2.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mAdc
   VCEO(sus) = 40 Vdc (Min) 2N6034, 2N6037
  - = 60 Vdc (Min) 2N6035, 2N6038 = 80 Vdc (Min) - 2N6036, 2N6039
- Forward Biased Second Breakdown Current Capability
   I<sub>S/b</sub> = 1.5 Adc @ 25 Vdc
- Monolithic Construction with Built-In Base-Emitter Resistors to Limit Leakage Multiplication
- Space-Saving High Performance-to-Cost Ratio TO-126 Plastic Package

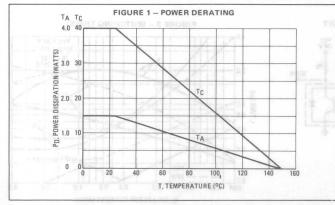
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6034 2N6037	2N6035 2N6038	2N6036 2N6039	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	5.0	-	Vdc
Collector Current — Continuous Peak	Ic	1	— 4.0 — — 8.0 —	-	Adc
Base Current	I <sub>B</sub>	-	<del>-100</del>	-	mAdd
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	1	— 40 — — 0.32—	-	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	1	1.5 0.012 -	-	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{\sf JC}$	3.12	°C/W
Thermal Resistance, Junction to Ambient	$\theta_{JA}$	83.3	°C/W

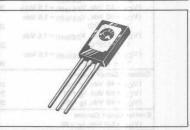
\*Indicates JEDEC Registered Data.

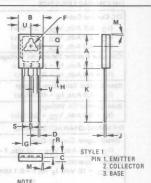


#### DARLINGTON 4-AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

40, 60, 80 VOLTS 40 WATTS

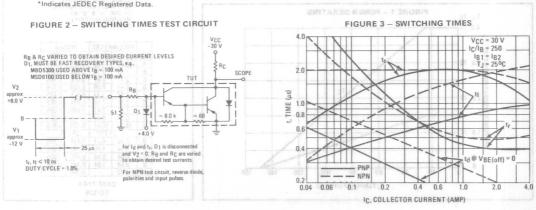




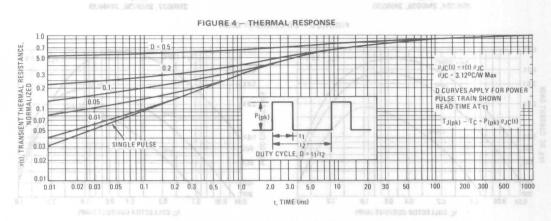
1. LEADS, TRUE POSITIONED
WITHIN 0.25 mm (0.010) DIA.
TO DIM. "A" & "B" AT
MAXIMUM MATERIAL
CONDITION.

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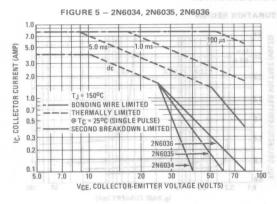
Characteristic		Symbol	Min	Max	Unit	_
OFF CHARACTERISTICS						
2 31 3 41 10 to	2N6034, 2N6037 2N6035, 2N6038 2N6036, 2N6039	VCEO (sus)	40 60 80	C DARLINI LICON POY r sendral-pur	Vdc	
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	2N6034, 2N6037 2N6035, 2N6038 2N6036, 2N6039	ICEO	- 2.0 Ade		High DC Cut hpg 20 Cut hpg 20	90
(V <sub>CE</sub> = 60 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 80 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)	2N6034, 2N6037 2N6035, 2N6038 2N6036, 2N6039	Xao <sup>1</sup> 2Nex30 3.2Nex30		100 100 100	VCEO(su	0
(V <sub>CE</sub> = 60 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc T <sub>C</sub> = 125°C) (V <sub>CE</sub> = 80 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc	2N6034, 2N6037 2N6035, 2N6038 2N6036, 2N6039	sse-Emitter	0	500 500	Is a distance.	0
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	2N6034, 2N6037 2N6035, 2N6038 2N6036, 2N6039	СВО	1 120(3-0) - 130(1) 	0.5 0.5 0.5	MITAR MU	a IX
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	2N6036 Unit	IEBO	Symbol 21	2.0	mAdc	
ON CHARACTERISTICS	380 V8c	40 60	OBSV	98	effoy istiling-	on
DC Current Gain  (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 3.0 Vdc)  (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc)  (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	5bV 98 5bV	0.8 0.8	500 750 100	15,000	Open Voltage Operett - Cor	113 1197 279
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 8.0 mAdc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 40 mAdc)	nAdic Watts	VCE(sat)	- g <sup>1</sup>	2.0	Vdc <sub>brien</sub>	Cu Po
Base-Emitter Saturation Voltage (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 40 mAdc)	30 VW	V <sub>BE</sub> (sat)	- <u>u</u> 9	4.0 3°85 = AT	Vdc	Po
Base-Emitter On Voltage (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	2a(	VBE(on)	- g <sub>2</sub> , T <sub>4</sub> , 7	2.8 notions	Vdc	1616
DYNAMIC CHARACTERISTICS				The same of the same of	agnish aluman	
Small-Signal Current-Gain (I <sub>C</sub> = 0.75 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 M	Hz) MnU	hfe	25 [odmy2	01:50	Charata Characta	No.
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> =0, f = 0.1 MHz) 2N6	6034, 2N6035, 2N6036 6037, 2N6038, 2N6039	C <sub>ob</sub>	AUB IN	200	ot enement	arr

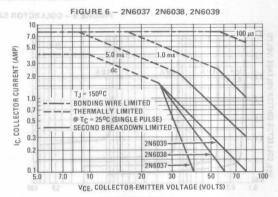






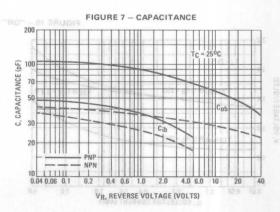
#### **ACTIVE-REGION SAFE-OPERATING AREA**





There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

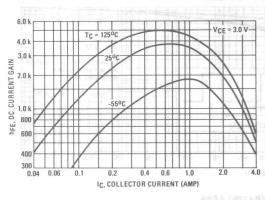
The data of Figures 5 and 6 is based on  $T_{J(pk)}$  =  $150^{o}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}$  <  $5150^{o}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



PNP 2N6034, 2N6035, 2N6036

NPN 2N6037, 2N6038, 2N6039

FIGURE 8 - DC CURRENT GAIN



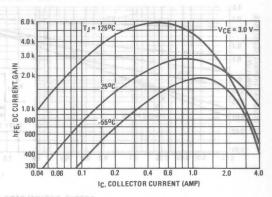
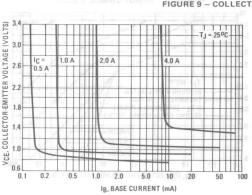


FIGURE 9 - COLLECTOR SATURATION REGION



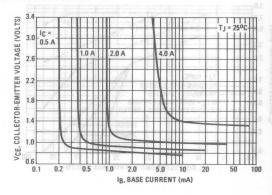
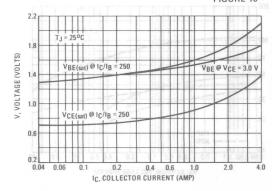
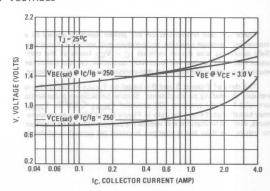


FIGURE 10 - "ON" VOLTAGES







# 2N6040 thru 2N6042 PNP 2N6043 thru 2N6045 NPN MJE6040 thru MJE6042 PNP MJE6043 thru MJE6045 NPN

#### PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain
  - hFE = 2500 (Typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mAdc (1)
  - VCEO(sus) = 60 Vdc (Min) 2N6040, 2N6043 = 80 Vdc (Min) 2N6041, 2N6044
    - = 100 Vdc (Min) 2N6042, 2N6045
- Low Collector-Emitter Saturation Voltage (1)
- VCE(sat) = 2.0 Vdc (Max) @ IC = 4.0 Adc 2N6040,41,2N6043,44 = 2.0 Vdc (Max) @ IC = 3.0 Adc - 2N6042, 2N6045
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
  - (1) Applies to corresponding in house part numbers also

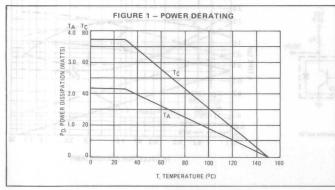
#### \*MAXIMUM RATINGS

Rating	Symbol			2N6042 2N6045 MJE6042 MJE6045	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	4	<u> </u>		Vdc
Collector Current - Continuous Peak	IC	4	— 8.0 — — 16 —	-	Adc
Base Current	IB	-	<del></del> 120	-	mAdc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	1	— 75 — — 0.60 —	-	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	4	- 2.2 - - 0.0175 -	-	Watts W/OC
Operating and Storage Junction, Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	65 to +15	50	°C

#### THERMAL CHARACTERISTICS

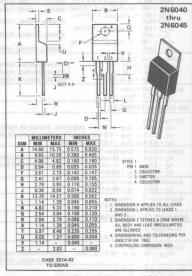
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	0 JC	1.67	°C/W
Thermal Resistance, Junction to Ambient	0 JA	57	°C/W

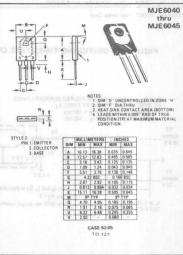
<sup>\*</sup>Indicates JEDEC Registered Data



DARLINGTON 8 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS 60-80-100 VOLTS

75 WATTS



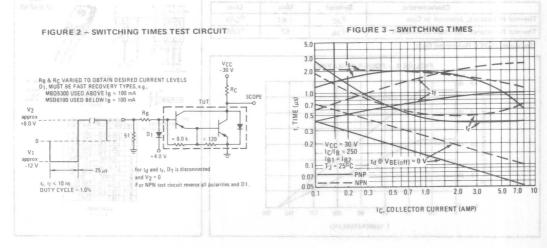


2N6040 thru 2N6042 PNP 2N6043 thru 2N6045 NPN MJE6040 thru MJE6042 PNP MJE6043 thru MJE6045 NPN

MIE 6043 thru MIE 6045 NPN



Characteristic	Symbol	T La Min	Max A TIMA	Unit
OFF CHARACTERISTICS OF A ST	ner lations and b	as militares escri	sur-limination with In	ecoion .
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAde, I <sub>B</sub> = 0) 2N6040, 2N6043, MJE6040, MJE6041 MJE6044 2N6042, 2N6045, MJE6042, MJE6045	VCEO(sus)	60 80 100	urrent Cain -	eno a Vdcqa
Collector Cutoff Current (VCE = 60 Vdc, Ig = 0) 2N6040, 2N6043, MJE6040, MJE6043 (VCE = 80 Vdc, Ig = 0) 2N6041, 2N6044, MJE6041, MJE6044 (VCE = 100 Vdc, Ig = 0) 2N6042, 2N6045, MJE6042, MJE6045	CEO EAOR		20 915 115 20 20 20 20	Au Collector I
Collector Cutoff Current  (VCE = 60 Vdc, VBE(off) = 1.5 Vdc) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc) (VCE = 60 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C)  (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 100 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C)	V8045 2N 6040, 41, 2 2N 6042, 2NB	Inj 24/6941, 2 Im) - 2(46042, 2 Im) - 2(46042, 2 Im) @ 1c = 4.0 Add In Built-In Base-E	200	Au Lov Colta CE(sa
Collector Cutoff Current (VCg = 60 Vdc, IE = 0)	СВО	nouse parl numbus	20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 2	asilgg A (1).
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	IEBO	-	2.0 20 1017	mAdc MA
ON CHARACTERISTICS CADE	us Lanaus Lau	nagre		
DC Current Gain (IC = 4.0 Adc, VCE = 4.0 Vdc) 2N6040,41, 2N6043,44, MJE6040,41, MJE6043,44 (IC = 3.0 Adc, VCE = 4.0 Vdc) 2N6042, 2N6045, MJE6042, MJE6045 (IC = 8.0 Adc, VCE = 4.0 Vdc) All Types	A3 2340A4 2N 040 MJE6041 MJ 043 MJE6044 MJ	1000 1000 1000	20,000 20,000 — 95035	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 16 mAdc)   2N6040,41,2N6043,44,MJE6040,41,MJE6043,44 (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 12 mAdc)   2N6042,2N6045,MJE6042,MJE6045 (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 80 mAdc)   All Types	VCE(sat)	19 035V	2.0 2.0 4.0	V and Vdc and sel
Base-Emitter Saturation Voltage (IC = 8.0 Adc, IB = 80 mAdc)	VBE(sat)		4.5	Vdc
Base-Emitter On Voltage (IC = 4.0 Adc, VCE = 4.0 Vdc)	VBE(on)		2.8	Vdc
DYNAMIC CHARACTERISTICS	- EV		OFET - AT IN and	solve C sweet la
Small-Signal Current Gain $(1_C = 3.0 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc}, f = 1.0 \text{ MHz})$	(h <sub>fe</sub> )	4.0	30 20	Desaits move 75
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz) 2N6040/2N6042, MJE6040/MJE6042 2N6043/2N6045, MJE6043/MJE6045	Cob		300 200	pF mayou armati
Small-Signal Current Gain	h <sub>fe</sub>	615	950	Tempe vin Ra



2N6040 thru 2N6042 PNP 2N6043 thru 2N6045 NPN MJE6040 thru MJE6042 PNP MJE6043 thru MJE6045 NPN

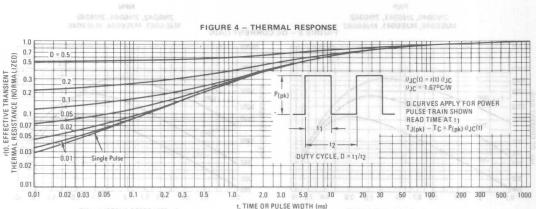
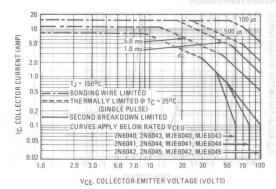


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA

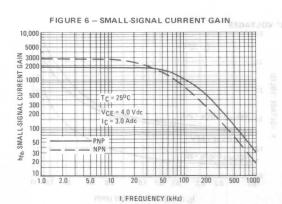


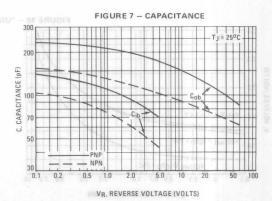
Safe operating area curves indicate I<sub>C</sub> - V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

There are two limitations on the power handling ability of a

transistor: average junction temperature and second breakdown.

The data of Figure 5 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

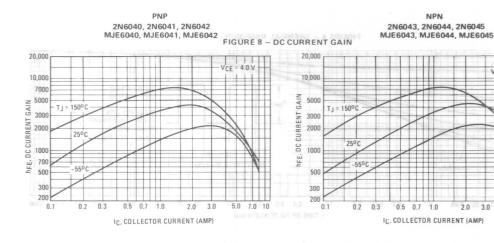


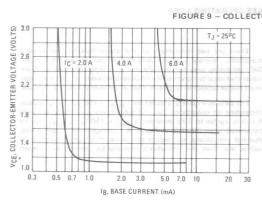


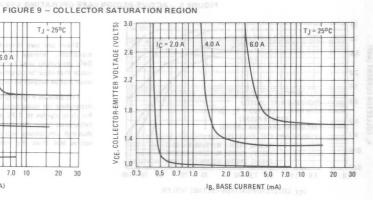
3.0

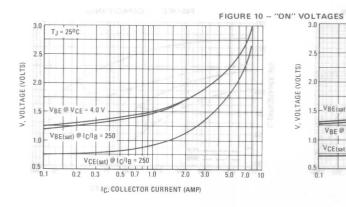
5.0 7.0 10

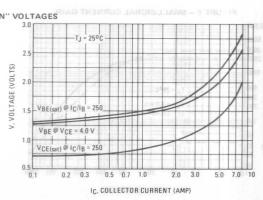
NPN













#### MEDIUM-POWER PNP SILICON TRANSISTOR

... designed for general-purpose switching and amplifier applications

- Excellent Safe Operating Area
- DC Current Gain Specified to 4.0 Amperes
- Complement to NPN Type 2N3054A

4 AMPERE
POWER TRANSISTOR
PNP SILICON
55 VOLTS
75 WATTS

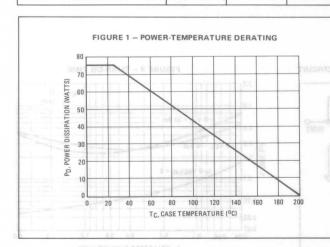
#### \*MAXIMUM RATINGS

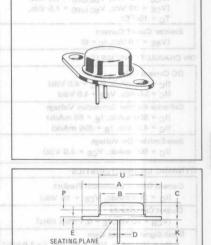
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	983 55	Vdc
Collector-Emitter Voltage	VCER	60	Vdc
(R <sub>BE</sub> = 100 Ω)			
Collector-Base Voltage	V <sub>CB</sub>	90	Vdc
Emitter-Base Voltage	VEB	7.0	Vdc
Collector Current — Continuous	¹c ,	4.0	Adc
Peak		10	
Base Current 0.2	I <sub>B</sub>	2.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C	PD	75	Watts
Derate above 25 <sup>0</sup>		0.43	W/OC
Operating and Storage Junction, Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	oC

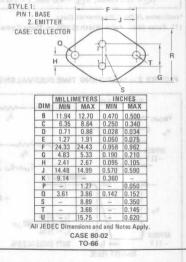


#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance,	0 JC	2.33	°C/W
Junction to Case	7.		





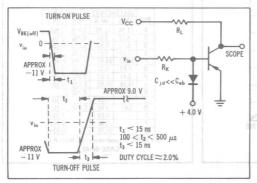


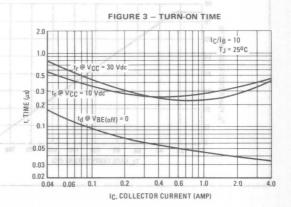
BABAMA Characteristic		Symbol			Min	Max	Unit
FF CHARACTERISTICS HENDY	699,012-9						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)		V <sub>CEO</sub> (su	ıs)	esió de	55 pni	ent Sale Operat	leox: Vdc
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, R <sub>BE</sub> = 100 Ω)		VCER(su	ıs)	A2608	60	MRM of remel	Vdc Vdc
Collector Cuttoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)		ICEO			_	500	μAdc
Collector Cutoff Current (VCE = 90 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc) (VCE = 90 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc,		ICEX			-	6.0	mAdc MUARXARM
$T_{C} = 150^{\circ}C)$	tinU	quisV	lps	myR		Parios	
Emitter Cutoff Current (VBE = 7.0 Vdc, I <sub>C</sub> = 0)		IEBO	0	gpV	-	1.0	mAdc
N CHARACTERISTICS (1)				-		(12.00	r = 33 <b>9</b> )
DC Current Gain (IC = 500 mAdc, VCF = 4.0 Vdc)	abV	ge hFE		οV	25	100	Collector Ba
(IC = 3.0 Adc, VCE = 4.0 Vdc)		7.0	8	6.0		epar lo V	Emire Gest
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 500 mAdc, I <sub>R</sub> = 50 mAdc)	20024	VCE (sat	t)	31		0.5	Vdc
(I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 800 mAdc)	ob.A	2.0		91	-	2.0	Base Curent
Base-Emitter On Voltage	arretiv	VBE(or	1)	C9			
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 4.0 Vdc)		0.43				1.0 as eve	de est 1G
YNAMIC CHARACTERISTICS	30	-65 to ±200	gli	Tail		Storage Junetion	Operar ng an
Current Gain — Bandwidth Product	100 min - 1 mi	f <sub>T</sub>		-	3.0	sgnaR etil sraO burersigoR 3	MHz
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 10 Vdc)				-			
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	tinii	C <sub>ob</sub>	Title	lucu2	201	200	DIAMPERAT
Small-Signal Current Gain (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 kHz)	M/3e	18.5 hfe		DL D	25	180	Tistmet Bes

<sup>\*</sup>Indicates JEDEC Registered Data

<sup>(1)</sup> Pulse test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%







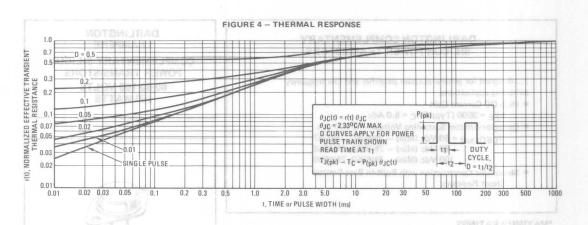
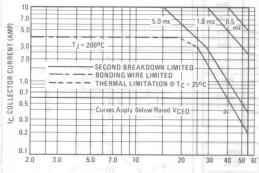


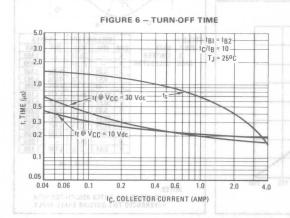
FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA

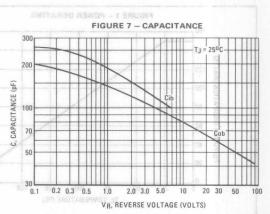


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)







#### DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general-purpose amplifier and low frequency switching applications.

- High DC Current Gain
  - hFE = 3500 (Typ) @ IC = 5.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mA
   VCEO(sus) = 60 Vdc (Min) 2N6050, 2N6057
   80 Vdc (Min) 2N6051, 2N6058
   100 Vdc (Min) 2N6052, 2N6059
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

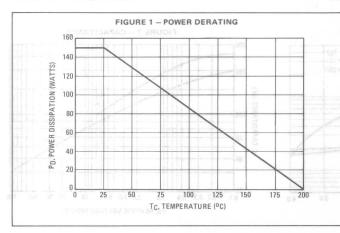
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6050 2N6057	2N6051 2N6058	2N6052 2N6059	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	60	80	100	Vdc
Emitter-Base Voltage	VEB	A	5.0	-	Vdc
Collector Current - Continuous Peak	IC	-	12 20		Adc
Base Current	IB	DECLOSION NEW	0.2	-	Adc
Total Device Dissipation  @T <sub>C</sub> = 25°C  Derate above 25°C	PD o Peased ai through a	of Figure 5	— 150 — — 0.857 —		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	Distr. 2015. 11. D.	65 to +200 <sup>0</sup>	1	°C

#### THERMAL CHARACTERISTICS

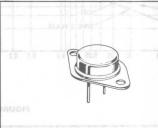
Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.17	oc/M

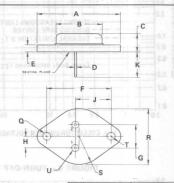
<sup>\*</sup>Indicates JEDEC Registered Data



#### DARLINGTON 12 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS 60-80-100 VOLTS 150 WATTS





TYLE 1			MILLIN	METERS	INC	HES
PIN 1.	BASE	DIM	MIN	MAX	MIN	MAX
2.	EMITTER	Α	-	39.37	-	1,550
CASE	COLLECTOR	В	-	21.08	-	0.830
		C	6.35	7.62	0.250	0.300
	D	0.97	1.09	0.038	0.043	
		E	1.40	1.78	0.055	0.070
		· F	29.90	30.40	1.177	1.197
		G	10.67	11.18	0.420	0.440
		H	5.33	5.59	0.210	0.220
	J	16.64	17.15	0.655	0.675	
		K	11.18	12.19	0.440	0.480
		0	3.81	4.19	0.150	0.165
		R	-	26.67	_	1.050
		U	2.54	3.05	0.100	0.120

CASE1-04

NOTES: 1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

*ELECTRICAL CHARACTERISTICS (Tc = 25°C un	ess otherwise noted
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Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					0750
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N6050, 2N6057 2N6051, 2N6058 2N6052, 2N6059	VCEO(sus)	60 80 100		Vdc
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 40 Vdc, I <sub>B</sub> = 0) (VCE = 50 Vdc, I <sub>B</sub> = 0)	2N6050, 2N6057 2N6051, 2N6058 2N6052, 2N6059	CEO		1.0 1.0 1.0	mAdc
Collector Cutoff Current (VCE = Rated VCEO, VBE(off) = 1.5 Vdc) (VCE = Rated VCEO, VBE(off) = 1.5 Vdc, T	C = 150°C)	ICEX		0.5 5.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	OF 0.8 0.2 0.5	IEBO	0.1 0.2 0.3	2.0	mAdc
ON CHARACTERISTICS (1)	(2001) 日間洋 3				
DC Current Gain (I <sub>C</sub> = 6.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 12 Adc, V <sub>CE</sub> = 3.0 Vdc)	SAFE OPERATING AR	MOIOSE 3V	750 100	18,000	CONTRACTOR OF THE CONTRACTOR O
Collector-Emitter Saturation Volatage (I <sub>C</sub> = 6.0 Adc, I <sub>B</sub> = 24 mAdc) (I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 120 mAdc)	Jun.10	VCE(sat)	= 18	2.0 3.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 120 mAdc)	17/1/1	V <sub>BE</sub> (sat)	- 1	4.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 6.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	. W/ / Marin 8.0	V <sub>BE</sub> (on)	- 1	2.8	Vdc

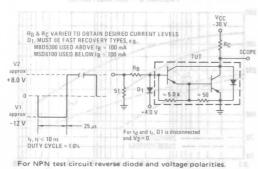
#### DYNAMIC CHARACTERISTICS

Magnitude of Common Emitter Small-Signal Short Circui Current Transfer Ratio ( $I_C = 5.0$ Adc, $V_{CE} = 3.0$ Vdc, $f = 1.0$ MHz)	t Forward	h <sub>fe</sub>	4.0	1/4	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	2N6050/2N6052 2N6057/2N6059	C <sub>ob</sub>	- 1	500 300	pF 1.0
Small-Signal Current Gain (IC = 5.0 Adc, VCE = 3.0 Vdc, f = 1.0 kHz)	07 Ge 90 70	h <sub>fe</sub>	300	30 56 N	0 0r

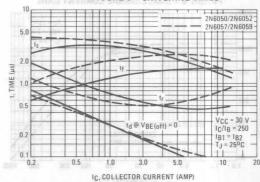
\*Indicates JEDEC Registered Data

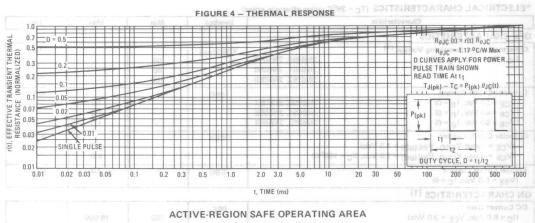
(1) Pulse test: Pulse Width = 300 µs, Duty Cycle = 2.0%.

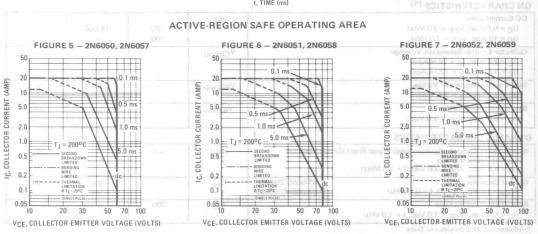
FIGURE 2 - SWITCHING TIMES TEST CIRCUIT





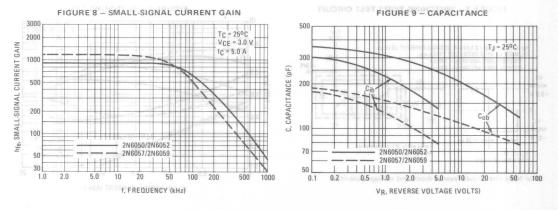






There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5, 6 and 7 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 200^{\circ}C$   $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

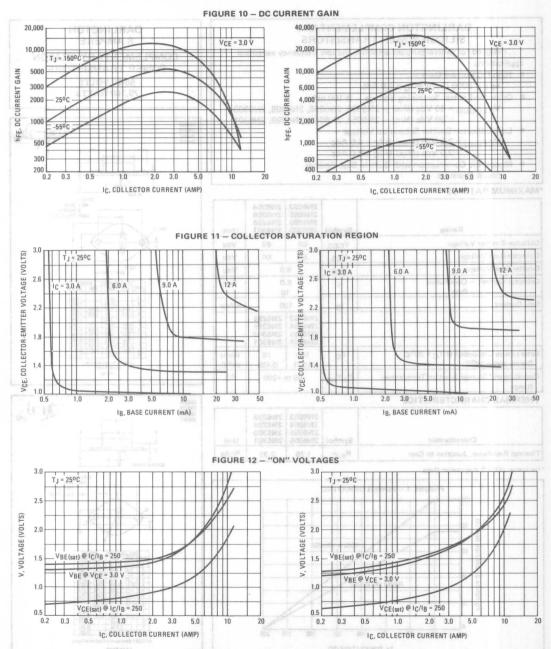




PNP 2N6050, 2N6051, 2N6052

NPN 2N6057, 2N6058, 2N6059

2N6055, 2N6056, 2N6300, 2N6301 NPN





## DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

 $\ldots$  designed for general-purpose amplifier and low frequency switching applications.

- High DC Current Gain
  - hFE = 3000 (Typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mA
   VCEO(sus) = 60 Vdc (Min) 2N6053, 2N6055, 2N6298, 2N6300
   = 80 Vdc (Min) 2N6054, 2N6056, 2N6299, 2N6301
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 2.0 Vdc (Max) @ IC = 4.0 Adc
   = 3.0 Vdc (Max) @ IC = 8.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

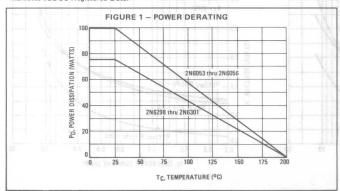
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6053 2N6055 2N6298 2N6300	2N6054 2N6056 2N6299 2N6301	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current — Continuous Peak	lc	8.0 16		Adc
Base Current	IB	120		mAdc
		2N6053 2N6054 2N6055 2N6056	2N6298 2N6299 2N6300 2N6301	
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	100 0.571	75 0.428	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

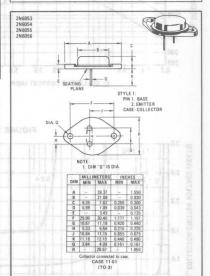
. Characteristic	Symbol	2N6055	2N6299 2N6300	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	2.33	°C/W

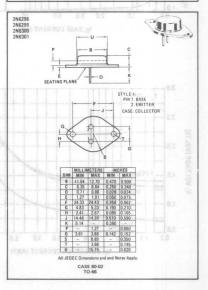
\*Indicates JEDEC Registered Data.



#### DARLINGTON 8 AMPERE

COMPLEMENTARY SILICON
POWER TRANSISTORS
60-80 VOLTS
75.100 WATTS





#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N6053, 2N6055, 2N6298, 2N6300 2N6054, 2N6056, 2N6299, 2N6301	VCEO(sus)	60 80	10-	Vdc
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 40 Vdc, I <sub>B</sub> = 0)	2N6053, 2N6055, 2N6298, 2N6300 2N6054, 2N6056, 2N6299, 2N6301	ICEO	30,77,3,78	0.5 0.5	mAdo
Collector Cutoff Current (VCE = Rated VCB, VBE(off) = 1.5 Vc		ICEX		0.5	mAdo
(V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 1.5 V <sub>C</sub>	dc, T <sub>C</sub> = 150 <sup>o</sup> C)	1.6 2.0	C0 <u>2</u> 0	5.0	1.8
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO		2.0	mAdo

#### ON CHARACTERISTICS (1)

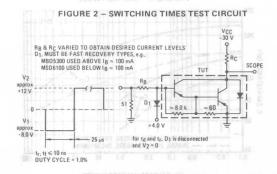
DC Current Gain (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	hFE	750 100	18000	- 100.
Collector-Emitter Saturation Voltage (IC = 4.0 Adc, IB = 16 mAdc) (IC = 8.0 Adc, IB = 80 mAdc)	V <sub>CE</sub> (sat)		2.0 3.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 80 mAdc)	V <sub>BE(sat)</sub>		4.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	V <sub>BE</sub> (on)	LT ARBY (1410) MALLY LAMB	2.8	Vdc

#### DYNAMIC CHARACTERISTICS

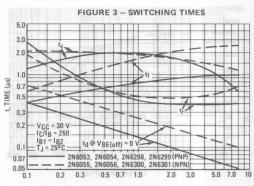
Magnitude of Common Emitter Small-Signal Short Circuit Current Transfer Ratio (I $_{\rm C}$ = 3.0 Adc, V $_{\rm CE}$ = 3.0 Vdc, f = 1.0 MHz)	h <sub>fe</sub>	4.0		
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz) 2N6053, 2N6054, 2N6298, 2N6299 2N6055, 2N6056, 2N6300, 2N6301	C <sub>ob</sub>	nytta <del>u</del> spty	300 200	pF
Small-Signal Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 kHz)	h <sub>fe</sub>	300	nitamul agen ni agviva apii na apviva api	milianer in the operation of must be

<sup>\*</sup>Indicates JEDEC Registered Data.

<sup>(1)</sup> Pulse Test: Pulse Width = 300  $\mu_{\text{S}},$  Duty Cycle = 2.0 %.

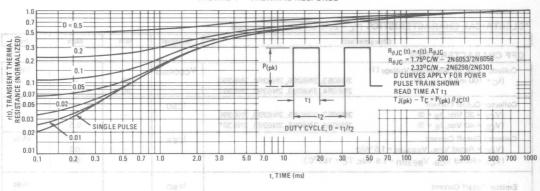


For NPN test circuit reverse diode, polarities and input pulses.

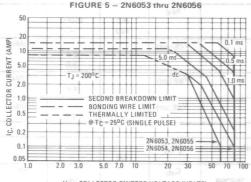


IC, COLLECTOR CURRENT (AMP)

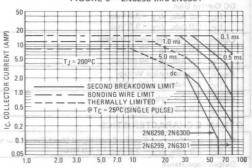




#### ACTIVE-REGION SAFE OPERATING AREA



#### FIGURE 6 - 2N6298 thru 2N6301



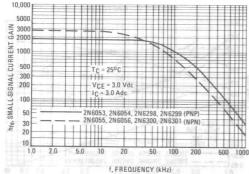
#### VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $1_{\rm C} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figures 5 and 6 is based on  $T_{\rm J(pk)} = 200^{\rm o}{\rm C}$ ;  $T_{\rm C}$  is

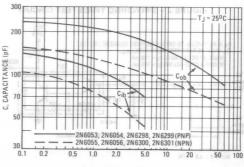
VCE, COLLECTOR EMITTER VOLTAGE (VOLTS)

variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ(p_k) \leq 200^{\circ}C.^{\circ}TJ(p_k)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. variable depending on conditions. Second breakdown





#### FIGURE 8 - CAPACITANCE



VR, REVERSE VOLTAGE (VOLTS)

3-178



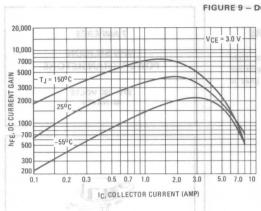


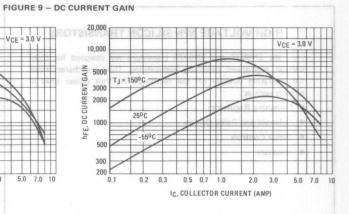
AJOROTOM

#### 2N6053, 2N6054, 2N6298, 2N6299

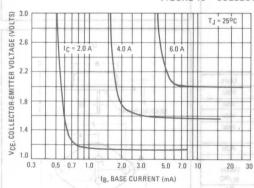
#### NPN

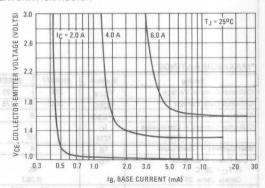
#### 2N6055, 2N6056, 2N6300, 2N6301



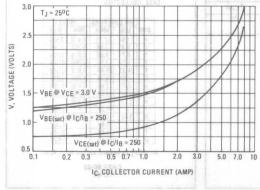


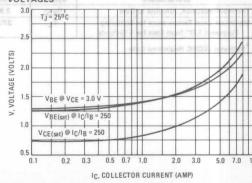
#### FIGURE 10 - COLLECTOR SATURATION REGION











### HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . the 2N6077 and 2N6078 transistors are designed for highvoltage, high-speed switching applications. They are characterized for operating directly off the rectified 110 Volt power lines in circuits such as:

- Switching Regulators
- Solenoid and Relay Drivers
- Motor Controls
- Inverters

7 AMPERES

NPN SILICON POWER TRANSISTORS

> 275-300 VOLTS 45 WATTS



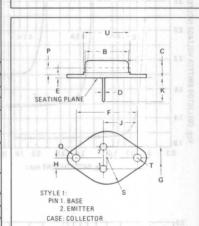
#### \*MAXIMUM RATINGS

mi otimom mitino				
Rating	Symbol	2N6077	2N6078	Unit
Collector-Emitter Voltage	VCEX	300	275	Vdc
Collector-Base Voltage	VCBO	300	275	Vdc
Emitter-Base Voltage	VEBO		6	Vdc
Collector Current — Continuous — Peak	I <sub>C</sub>	1	7	Adc
Base Current - Continuous	IB	TUIT !	4 8	Adc
Total Power Dissipation  © T <sub>C</sub> = 25°C  Derate above 25°C	PD <sub>0.1</sub>	45 0.257		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	o +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	3.9	°C/W
Maximum Lead Temperature for Soldering	TL	275	°C
Purposes: 1/8" from Case for 5 Seconds			11000

\*Indicates JEDEC Registered Data



	MILLI	METERS	IN	CHES
DIM	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
Н	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	-	0.360	-
P	4	1.27	-	0.050
0	3.61	3.86	0.142	0.152
S	-	8.89	-	0.350
T	13	3.68	1 -	0.145
U	actor of	15.75	COL 753/	0.620

All JEDEC Dimensions and and Notes Apply.

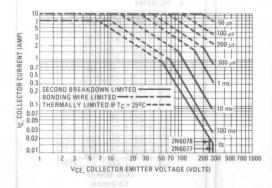
CASE 80-02 TO-66

\*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

	Characteristic			Symbol	Min	-	Max		Unit	+
OFF CHARACTE	RISTICS			ON PLASTIC	OLUI2 V	TAR	LEMEN	SMC	30	_
$(I_C = 200 \text{ mA})$	Sustaining Voltage (Table 1)		N6077 N6078	VCEO(sus)	275 250	AT A	POWE ni esti n	oi to	Vdc	
Emitter Cutoff Cu (VBE = 6 Vdc,				IEBO	7.0 Ampe		1.0		mAdc	1
	Ourrent	C) 2	N6077 N6078 N6077 N6078	I ZNGZOJ	A — obA — spatio	o.t≃ V gain taiMl	5.0 0.05 8,0	2.3 Emin	mAdc	
Collector Cutoff C	Current dc, V <sub>BE(off)</sub> = 1.5 Vdc)	2	N6077	ICEO	- 2N610	(nily) Niwh	2.0	1 time	mA	
N CHARACTE	RISTICS		00.7				in Indian		A = v l	
DC Current Gain (I <sub>C</sub> = 1.2 Adc,	V <sub>CE</sub> = 1 Vdc)		11.3	c = 233407, 0	0Am 003	× 21	70			]
Collector-Emitter (I <sub>C</sub> = 1.2 Adc,	Saturation Voltage I <sub>B</sub> = 0.2 Adc)		N6077 N6078	VCE(sat)	-51	vailab	0.5		Vdc	
(I <sub>C</sub> = 3 Adc, I <sub>E</sub> (I <sub>C</sub> = 5 Adc, I <sub>E</sub>			N6077 N6078		_		1.0 3.0		HTAR MUM	26
Base-Emitter Satu (I <sub>C</sub> = 1.2 Adc,			N6077	V <sub>BE</sub> (sat)	2346.251 -2146.260	Sortes	1.6		Vdc	
(I <sub>C</sub> = 3 Adc, I <sub>E</sub> (I <sub>C</sub> = 5 Adc, I <sub>E</sub>		2	N6078 N6077 N6078	00	30	690	1.9 2.0		oV 187 112-102 parfo V maB-102	-
YNAMIC CHAI	RACTERISTICS	20.9				18		THE REAL PROPERTY.	Ingel 2   On the last of	
Current-Gain - Ba	andwidth Product dc, VCE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	280 Pk	-	h <sub>fe</sub>	1.0	of		den	MHz	1
WITCHING CH	ARACTERISTICS	51275		V-0		1.91			1186.252	100
Resistive Load (Ta	able 1)	SHEET	-	Ob	1	0.7		110	POWER CHIPPED	1
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 1.2 Adc,	3ºW		ctro-			0.75		μs	1
Storage Time	I <sub>B1</sub> = I <sub>B2</sub> = 200 mAdc = 100 μs,			ts	-		5.0	wut.	μs	
Fall Time	Duty Cycle ≤ 2.0%)		-	tf	1	978	0.75		из из	-

\* Indicates JEDEC Registered Data

FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe Operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 12 and 13 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 1.

# COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

 $\ldots$  designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 7.0 Amperes
  - h<sub>FE</sub> = 30-150 @ I<sub>C</sub> = 3.0 Adc 2N6111, 2N6288 = 2.3 (Min) @ I<sub>C</sub> = 7.0 Adc - All Devices
- Collector-Emitter Sustaining Voltage —

V<sub>CEO</sub>(sus) = 30 Vdc (Min) - 2N6111, 2N6288 = 50 Vdc (Min) - 2N6109, 2N6290

= 50 Vdc (Min) - 2N6109, 2N6290 = 70 Vdc (Min) - 2N6107, 2N6292

High Current Gain — Bandwidth Product

 $f_T$  = 4.0 MHz (Min) @  $I_C$  = 500 mAdc - 2N6288, 90, 92 = 10 MHz (Min) @  $I_C$  = 500 mAdc - 2N6107, 09, 11

- TO-220AB Compact Package
- TO-66 Leadform Also Available

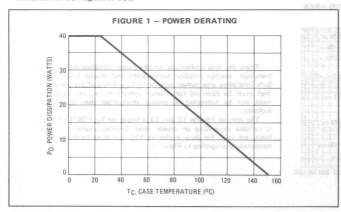
#### \*MAXIMUM RATINGS 0.8

Symbol	2N6111 2N6288	2N6109 2N6290	2N6107 2N6292	Unit
VCEO	30	50	70	Vdc
VCB	40	60	80	Vdc
VEB		5.0	1	Vdc
Ic		7.0 — 10 —	-	Adc
I <sub>B</sub>	4	— 3.0 —	-	Adc
PD	4	— 40 — — 0.32 —	-	Watts W/OC
T <sub>J</sub> , T <sub>stg</sub>	4	65 to +150	-	°c
	VCEO VCB VEB IC IB	VCEO 30 VCB 40 VEB IC	Symbol         2N6288         2N6290           VCEO         30         50           VCB         40         60           VEB         5.0           IC         7.0           IB         3.0           PD         40           -0.32	Symbol         2N6288         2N6290         2N6292           VCEO         30         50         70           VCB         40         60         80           VEB         5.0           IC         10         10           IB         3.0         10           PD         40         10           -0.32         -0.32         -0.32

#### THERMAL CHARACTERISTICS

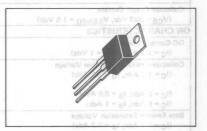
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	3.125	°C/W

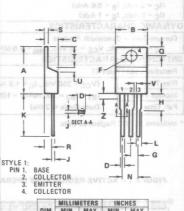
<sup>\*</sup>Indicates JEDEC Registered Data



# 7 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

30-50-70 VOLTS 40 WATTS 40 WATTS

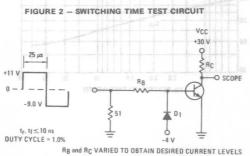




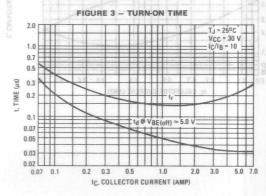
	MITTIN	IE IENS	INC	HF2
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	C.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.14	-	0.045	-
Z	- 02	2.03	-	0.080
		SE 22		

Characteristic		Symbol	Min	Max	Unit
OFF-CHARACTERISTICS				T. HILLST	
Collector-Emitter Sustaining Voltage (1)	IAD/9	VCEO(sus)	-		Vdc
(IC = 100 mAdc, IR = 0) 2N61	11, 2N6288	020(303)	30		
A REVISE ROT YURA ZEVRUS D 2N61	09, 2N6290		50		
MWONE MART REALIS 2N61	07, 2N6292		70		
Collector Cutoff Current		ICEO			mAdc
(VCE = 20 Vdc, IB = 0) 2N61	111,2N6288			1.0	
(VCE = 40 Vdc, IB = 0) 2N61	109, 2N6290			1.0	
(VCE = 60 Vdc, IB = 0) 2N61	07, 2N6292			1,0	
Collector Cutoff Current	0,0	ICEX	8.0 7.63	-1.0- eno	μAdc
(VCE = 40 Vdc, VEB(off) = 1.5 Vdc) 2N61	111, 2N6288	MILL I SEL	- 1	100	
(VCE = 60 Vdc, VEB(off) = 1.5 Vdc) 2N61	109, 2N6290		- 1	100	
(VCE = 80 Vdc, VEB(off) = 1.5 Vdc) 2N61	107, 2N6292		- 1	100	
(VCE = 30 Vdc, VEB(off) = 1.5 Vdc, TC = 150°C) 2N61	111, 2N6288			2.0	mAdc
(VCE = 50 Vdc, VEB(off) = 1.5 Vdc, TC = 150°C) 2N61			FIGURE 5 - A	2.0	
(VCE = 70 Vdc, VEB (off) = 1.5 Vdc, TC = 150°C) 2N61	107, 2N6292		and the same of	2.0	somitteeningstets
Emitter Cutoff Current		IEBO		1.0	mAdc
(VBE = 5.0 Vdc, IC = 0)	to a second Tri	V 5.0 mm			100
ON CHARACTERISTICS (1)	e noteianest		7 7		3-00
DC Current Gain in to stimil 30 V-51 etecioni sevous sens g	Safe operating	hFE /			
(IC = 2.0 Adc, VCE = 4.0 Vdc) 2N61	107, 2N6292		30	150	35 -
(I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 4.0 Vdc) 2N61			30	150	28
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc) 2N61	111, 2N6288	let the second	30	mon a 150 James	HT STATE
(I <sub>C</sub> = 7.0 Adc, V <sub>CE</sub> = 4.0 Vdc) AII D	Devices		2.3	T 7c = 280c	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 7.0 Adc, I <sub>B</sub> = 3.0 Adc)	calculated fro thermal limits	VCE(sat)	Atl	3.5	Vdc
Base-Emitter On Voltage user voltage and herostrum and her (I <sub>C</sub> = 7.0 Adc, V <sub>CE</sub> = 4.0 Vdc)		VBE(on)		2.000 3.000 Common	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain - Bandwidth Product (2)		f <sub>T</sub>	38 50	08	MHz
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 4.0 Vdc, f <sub>test</sub> = 1.0 MHz)			VOLTAGE (VOLTS)	ASTTIME-ROYSS.L10	
2N6288, 90, 92			4.0	- 1	
2N6107, 09, 11			10		
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 1.0 MHz)		C <sub>ob</sub>	BMIT 9	10-ия250 — а зі	IUBIR PF
Small-Signal Current Gain (IC = 0.5 Adc, VCE = 4.0 Vdc, f = 50 kHz)	000	h <sub>fe</sub>	20		1 1

\*Indicates JEDEC Registered Data. (1)Pulse Test: Pulse Width  $\leq 300~\mu$ s, Duty Cycle  $\leq 2.0\%$ . (2) $f_T = |h_{fe}| \circ f_{test}$ 

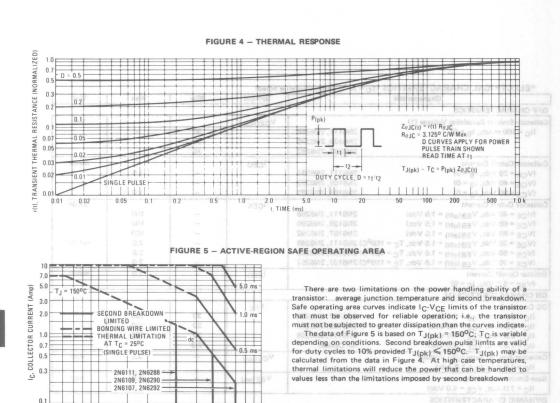


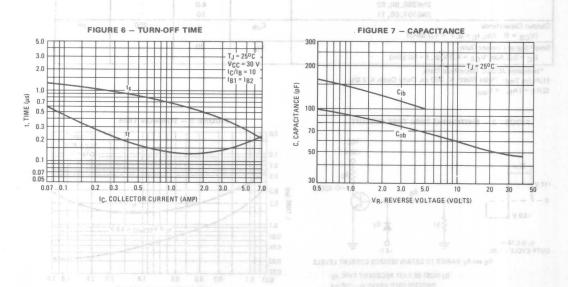
D<sub>1</sub> MUST BE FAST RECOVERY TYPE, eg: MBD5300 USED ABOVE I<sub>B</sub> ≈100 mA MSD6100 USED BELOW I<sub>B</sub> ≈100 mA



7.0

10 20 30 50 V<sub>CE</sub>, COLLECTOR-EMITTER VOLTAGE (VOLTS)







#### COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTORS**

. . . designed for use in power amplifier and switching circuits, packaged in the compact TO-220AB outline. TO-66 leadform also available.

#### \*MAXIMUM RATINGS

Rating	Symbol	2N6121 2N6124	2N6122 2N6125	2N6123 2N6126	Unit
Collector-Emitter Voltage	VCEO	45	60	80	Vdc
Collector-Base Voltage	VCB	45	60	80	Vdc
Emitter-Base Voltage	VEB	-	5.0	-	Vdc
Collector Current	1c	-	4.0 —	-	Adc
Base Current	1 <sub>B</sub>	4	1.0 —	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	4	40 320	140 no1 >	Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	4	65 to +150	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	3.12	°C/W

#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		VCEO(sus)		17.19	Vdc
(I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	2N6121, 2N6124	020(303)	45	-	
	2N6122, 2N6125		60	-	7
	2N6123, 2N6126		80	-	
Collector Cutoff Current		ICEO			mAdd
(VCF = 45 Vdc, IB = 0)	2N6121, 2N6124	CLO	-	1.0	
(VCF = 60 Vdc, IB = 0)	2N6122, 2N6125	- F 13 F	-	1.0	
(VCE = 80 Vdc, IB = 0)	2N6123, 2N6126		-	1.0	
Collector Cutoff Current		ICEX		100	mAdo
(V <sub>CE</sub> = 45 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc)	2N6121, 2N6124	CEA		0.1	
(VCE = 60 Vdc, VEB(off) = 1.5 Vdc)	2N6122, 2N6125		-	0.1	
(VCE = 80 Vdc, VEB(off) = 1.5 Vdc)	2N6123, 2N6126			0.1	
(VCE = 45 Vdc, VEB(off) = 1.5 Vdc,	2N6121, 2N6124	81 8	5 -0.2	2.0	0 63
T <sub>C</sub> = 125°C)		District N	MERRI	0.300.0	.pt
(V <sub>CE</sub> = 60 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 125°C)	2N6122, 2N6125	Danie .	-	2.0	13.
$(V_{CE} = 80 \text{ Vdc}, V_{EB(off)} = 1.5 \text{ Vdc}, $ $T_{C} = 125^{\circ}C)$	2N6123, 2N6126		-	2.0	
Collector Cutoff Current	C LANGERSHALL SHE	1сво			mAde
(V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0)	2N6121, 2N6124	11 11 11 1 23	v	0.1	773
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	2N6122, 2N6125			0.1	111
(VCB = 80 Vdc, IE = 0)	2N6123, 2N6126	THE PROPERTY AND ADDRESS OF THE PARTY AND ADDR	2 2	0.1	
Emitter Cutoff Current		IEBO		1.0	mAdd
(VBE = 5.0 Vdc, IC = 0)			222		
ON CHARACTERISTICS		7 13 12	9 6		
DC Current Gain (1)		hee	2		NIF
(IC = 1.5 Adc, VCE = 2.0 Vdc)	2N6126, 2N6124	A Interes	25	100	N
	2N6122, 2N6125		25	100	
	2N6123, 2N6126	1 331 6	20	80	
(IC = 4.0 Adc, VCE = 2.0 Vdc)	2N6121, 2N6124	11-12.1	10	-	-
00	2N6122, 2N6125		10		3.94
	2N6123, 2N6126		7.0	-	N. I
Collector-Emitter Saturation Voltage (1)		VCE(sat)	. 8		Vdc
(IC = 1.5 Adc, IB = 0.15 Adc)		CE (sat)	- 1	0.6	
(IC = 4.0 Adc, IB = 1.0 Adc)		4-4411	-	1.4	
Base-Emitter On Voltage (1)		V <sub>BE</sub> (on)		1.2	Vdc
(IC = 1.5 Adc, VCF = 2.0 Vdc)					B 0 0

<sup>(</sup>I<sub>C</sub> = 1.0 Adc, V<sub>CE</sub> = 4.0 Vdc, f = 1.0 MHz) (1) Pulse Test: Pulse Width  $\leq$ 300  $\mu$ s, Duty Cycle  $\leq$ 2.0% \*Indicates JEDEC Registered Data.

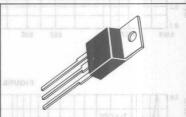
(I<sub>C</sub> = 0.1 Adc, V<sub>CE</sub> = 2.0 Vdc, f = 1.0 kHz)

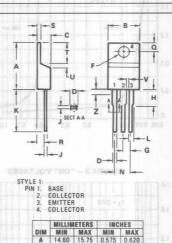
Current-Gain-Bandwidth Product

Small-Signal Current Gain

#### 4 AMPERE **POWER TRANSISTORS COMPLEMENTARY SILICON** 45-80 VOLTS

40 WATTS





	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
E	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

TO-220AB

25

2.5

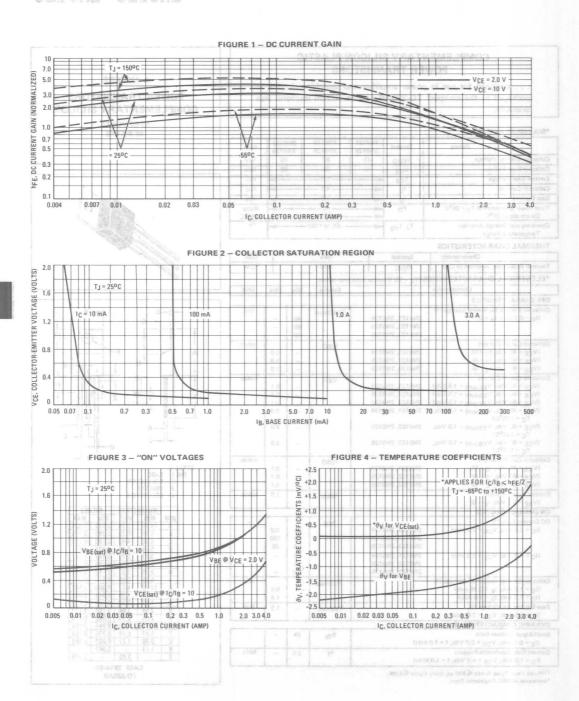
MHz

hfe

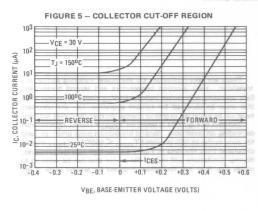
fT

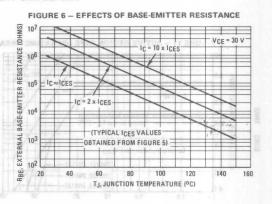
2N6121, 2N6122, 2N6123, NPN, 2N6124, 2N6125, 2N6126, PNP



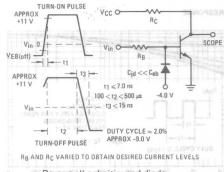


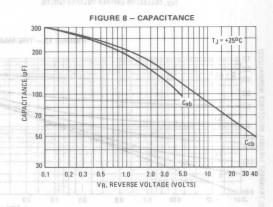
#### RATING AND THERMAL BATA





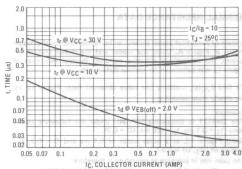
#### FIGURE 7 - SWITCHING TIME EQUIVALENT CIRCUIT



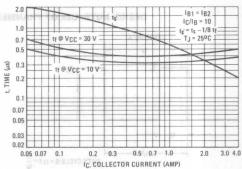


Reverse all polarities and diode for PNP transistors.

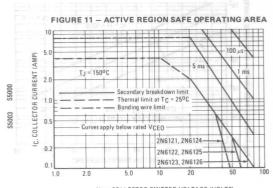
#### FIGURE 9 - TURN-ON TIME







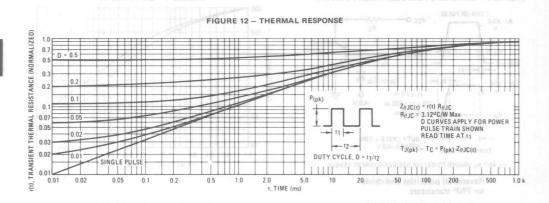
#### RATING AND THERMAL DATA



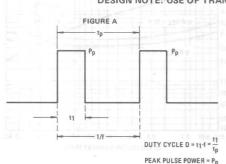
VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: peak junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on T<sub>J</sub>(pk) = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



#### DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find  $\theta_{JC}(t)$ , multiply the value obtained from Figure 12 by the steady state value  $\theta_{JC}$ .

#### Example:

The 2N6121 is dissipating 50 watts under the following conditions:  $t_1 = 0.1$  ms,  $t_p = 0.5$  ms. (D = 0.2).

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r(t<sub>1</sub>, D) is 0.27.

The peak rise in junction temperature is therefore:

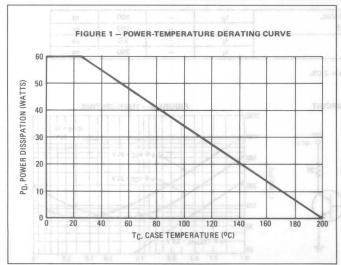
 $\Delta T = r(t) \times PP \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2^{\circ}C$ 

#### MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.2 Vdc (Max) @ IC = 10 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration
- Complement to NPN 2N5346 thru 2N5349

*MAXIMUM RATINGS  Rating	Symbol	2N6186 2N6187	2N6188 2N6189	Unit
	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	6	.0	Vdc
Collector Current — Continuous	1c	10		Adc
Base Current	1 <sub>B</sub>	2.0		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	60 343		Watts mW/O
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C
THERMAL CHARACTERISTICS	ne l	-		(sH
Characteristic	Symbol	M	ax	Unit
Thermal Resistance, Junction to Case	θJC	2	.91	°C/W

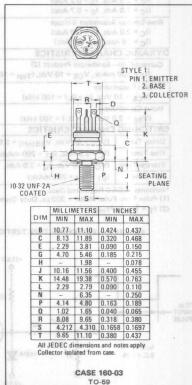


#### 10 AMPERE

#### **POWER TRANSISTORS** PNP SILICON

80-100 VOLTS 60 WATTS





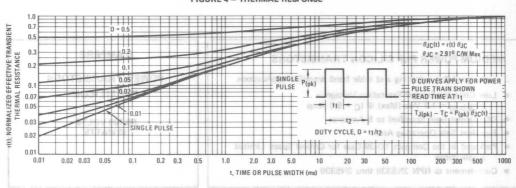


	Characteristic		Symbol	Min	Max	Unit	
FF CHARA	CTERISTICS						
	tter Sustaining Voltage (1) Adc, I <sub>B</sub> = 0)	2N6186, 87 2N6188, 89	VCEO(sus)	80 100	-	Vdc	
Collector Cuto	off Current	2110100,00	loso	100		μAdc	
(V <sub>CE</sub> = 75	Vdc, I <sub>B</sub> = 0) Vdc, I <sub>B</sub> = 0)	2N6186, 87 2N6188, 89	ON TRANSH	NP SELECE	100		
Collector Cuto	A SECURE AND ADDRESS OF THE PARTY OF THE PAR		ICEX			μAdc	
	Vdc, VEB(off) = 1.5 Vdc)	2N6186, 87	and emplifier a	and wide-b	10 = 10	benglasb	
	Vdc, VEB(off) = 1.5 Vdc)	2N6188,89	Veltage	Saturation	10	Low Collec	100
	Vdc, VEB(off) = 1.5 Vdc,			of 9 (xe/d)	Direction of the Control of the Cont	Lucianis/	
T <sub>C</sub> = 15		2N6186, 87			0.1 Spec	mAdc	io.
	Vdc, V <sub>BE</sub> (off) = 1.5 Vdc,	2N6188,89	Shackus		1.0		
Collector Cuto		2110100,00	lono	na Area	232 143452 4715	μAdc	
	ted V <sub>CB</sub> , I <sub>E</sub> = 0)		G-O-CBO	ict, High Di	o the Comp	Packaged w	19
Emitter Cutof			1 <sub>EBO</sub>	กดูเรียกแกเ	HECTOT COT	μAdc	90
$(V_{BE} = 6.0$	) Vdc, I <sub>C</sub> = 0)		21/5349	NE346 thru	19100	Complanu	w.
ON CHARAC	TERISTICS (1)						
DC Current G	ain	to a succession of the same	hFE			_	
$(I_C = 0.5 A)$	Adc, V <sub>CE</sub> = 2.0 Vdc)	2N6186, 88		30	-		
// 00	A. V	2N6187, 89	NAT SOME	60		WITAS MU	PIXA
(IC = 2.0 A	dc, V <sub>CE</sub> = 2.0 Vdc)	2N6186, 88 2N6187, 89	2N6 188 2N6187	30 60	120 240	eirasi	
(IC = 5.0 A	Adc, V <sub>CE</sub> = 2.0 Vdc)	2N6186, 88	08 030	20		deste V settimi	lector
		2N6187, 89	00 000	40		angelaV salf	- otoeli
Collector-Emi	tter Saturation Voltage	8.0 Vde	VCE(sat)	0		Vdc	2-vante
	dc, I <sub>B</sub> = 0.2 Adc)		1 83	-	0.7	Surrent - Col	rotoel
	Adc, I <sub>B</sub> = 0.7 Adc)	700			1.2	7111111	e Co
	Saturation Voltage		VBE(sat)		Dar and the	Vdc	v=O les
	dc, lg = 0.2 Adc) dc, lg = 1.0 Adc)	iss mw/cc		- '	1.2	shove 25°C	Derete
	HARACTERISTICS	50 005+81	ee-   gis1	17	1101130	L eggiotz bris	critiene
	-Bandwidth Product (2)		fT			MHz	Temor
	mAdc, VCE = 10 Vdc, fTest = 10	MHz)		30	DITEIRET	ARAHS JA	MRE
Output Capac		31(0.7) 30(0	Cob	NS	2031	pF	
(V <sub>CB</sub> = 10	Vdc, IE = 0, f = 100 kHz)		1 34	-	300	veistence, June	strat
Input Capacita	ance		Cib		ad Status	releopE so s	mapl
	) Vdc, IC = 0, f = 100 kHz)	Lancación de la companya de la compa		<del>-</del>	1250		
	CHARACTERISTICS	-				-	
Delay Time	(VCC = 40 Vdc, VEB(off) = 3.0		<sup>t</sup> d	-	100	ns	
Rise Time	(I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 200 mAdc	31/91/0-2	t <sub>r</sub>	ASSESSED !	100	ns	
	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc,		t <sub>s</sub>	_	2.0	μς	
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 200 mAdc)	and the same of the same of	tf	-	200	ns	n 38
1) Pulse Test: F (2) f <sub>T</sub> =  h <sub>fe</sub>   *	EC Registered Data. Pulse Width ≈ 300 μs, Duty Cycle Test	≈ 2.0%.					08
	2 - SWITCHING TIME TEST C		000.	FIGURE 3	- TURN-ON	TIME	10
	81.9 85 8 91 9 +11.6 V	Mag		All		IC/IB = 10	
6 (11)	N 2 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	VCC 1	000			T <sub>J</sub> = 25°C	
	0 Var 84 51 8		500	tr	@ VCC = 80 V		
0710	80.0 85.5 85.5 B	>	1				
B87.01 6	37 V 17 9 62	320		1 Lir	@ VCC = 20 V		
887 01	0 1.02 1.05 10.01	t. TIME (ns)	200				1
t vaar of ea	25 μF 82		100				
160.0	08.0 01.1 582						
$t_r$ , $t_f \le 10 \text{ ns}$ D.C. = 1.0%	hos anove by 510 10000 1N914	087 081	50		128		
D.C 1.0%	₹°'		230 3 3 3 3 3 3 3 3	11 2 2 6 11			+++
	-001 HBZ-	一	20 G WBE(0	off) = 3.0 V	1		
	98-0T +23V						

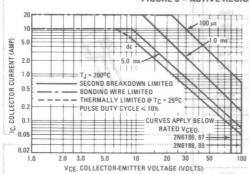
IC, COLLECTOR CURRENT (AMP)



#### FIGURE 4 - THERMAL RESPONSE



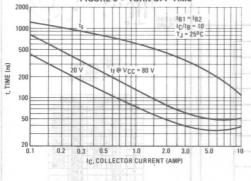
#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



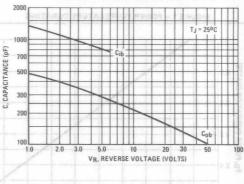
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic — VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}=200^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}<200^{\circ}\text{C}$ .  $T_{J(pk)}=700^{\circ}\text{C}$ .  $T_{J(pk)}=700^{\circ}\text{C}$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## FIGURE 6 - TURN-OFF TIME



#### FIGURE 7 - CAPACITANCE versus VOLTAGE



CASE TEMPERATURE IPC)



DISCOURT AND DESCRIPTION OF THE PROPERTY AND ADDRESS OF THE PROPERTY ADDRESS OF THE PROPER

#### MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 1.2 Vdc (Max) @ IC = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space Limited Applications
- Complement to NPN 2N5336 thru 2N5339 thru 2N5339 thru 3N5339 th

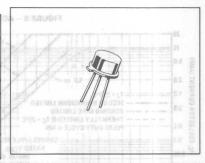
5 AMPERE

POWER TRANSISTORS
PNP SILICON

80-100 VOLTS 10 WATTS

#### \* MAXIMUM RATINGS

Rating	Symbol	2N6190 2N6191	2N6192 2N6193	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	80	100	Vdc
Emitter-Base Voltage	VEB	и претиль 6	O circums	Vdc
Collector Current — Continuous	¹c	5.0		Adc
Base Current and addressed versus a	a beal Bone a	5 con Jaum 1.0 signad		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C	PD	data of Figu	0	Watts
Derate above 25°C				mW/°C
Operating and Storage Junction Temperature Range		-65 to	°C	

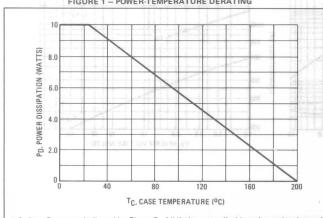


#### THERMAL CHARACTERISTICS

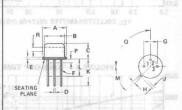
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	17.5	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data: MATIDARAO - 7 3811019

FIGURE 1 - POWER-TEMPERATURE DERATING



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



STYLE 1: PIN 1. EMITTER 2. BASE 3. COLLECTOR

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
В	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	-	0.500	-
L	6.35	-	0.250	
M	450 N	MOI	450 N	OM
P	-	1.27	-	0.050
0	900 N	IOM	90º N	MOI
R	2.54	-	0.100	-

All JEDEC dimensions and notes apply

CASE 79-02

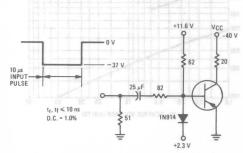
TO-39

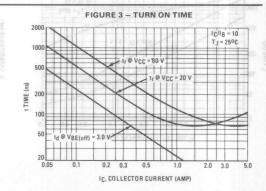
#### \* ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) | - | 3 3 4 4 5 4

	Characteristic			Symbol	Min	Max	Unit
OFF CHARACTE	RISTICS		- Land		1111	120 - 0 1	Martin 1
Collector-Emitter (I <sub>C</sub> = 50 mAdo	r Sustaining Voltage (1) ;, I <sub>B</sub> = 0)	2N6190, 2N6191 2N6192, 2N6193		VCEO(sus)	80 100		V <sub>dc</sub>
Collector Cutoff (V <sub>CE</sub> = 75 Vdc (V <sub>CE</sub> = 90 Vdc	c, (g = 0)	2N6190, 2N6191 2N6192, 2N6193	ISHIS	ICEO	-	100 100	μAdc
(V <sub>CE</sub> = 90 Vdc (V <sub>CE</sub> = 75 Vdc T <sub>C</sub> = 150°C)	Current  V BE(off) = 1.5 Vdc)  V BE(off) = 1.5 Vdc)  VBE(off) = 1.5 Vdc,  VBE(off) = 1.5 Vdc,	2N6190, 2N6191 2N6192, 2N6193 2N6190, 2N6191 2N6192, 2N6193		ICEX	38309 334	10 10 1.0	µAdc mAdc
Collector Cutoff (V <sub>CB</sub> = 80 Vdo (V <sub>CB</sub> = 100 Vd	c, IE = 0) 00 00	2N6190, 2N6191 2N6192, 2N6193	a p.c as	СВО	to 🖨	10	μAdc
Emitter Cutoff C		0-0110	THE CAMPENC OF	<sup>I</sup> EBO	_	100	μAdc
N CHARACTER	RISTICS (1)						
(I <sub>C</sub> = 2.0 Adc,	V <sub>CE</sub> = 2.0 Vdc) V <sub>CE</sub> = 2.0 Vdc) V <sub>CE</sub> = 2.0 Vdc)	2N6191, 2N6193 2N6190, 2N6192 2N6191, 2N6193 2N6190, 2N6192 2N6191, 2N6193	EGION SAFE	hFE 1 SVITOA - 6	30 60 30 60 20 40	120 240	
Collector-Emitte (I <sub>C</sub> = 2.0 Adc, (I <sub>C</sub> = 5.0 Adc,			Pratty Safet sieto	VCE (sat)		0.7	Vdc
Base-Emitter Sat (I <sub>C</sub> = 2.0 Adc, (I <sub>C</sub> = 5.0 Adc,		e ad too from rote is indicate.  s indicate to a so one in our in	Miro T	VBE (sat)	E NOTE - A	1.2 1.8	Vdc
YNAMIC CHAR		noa no priibrit qeo ek	STORY	DIAM I	3	ה מערץ פּיְפֶענּ< וֹפּ	10,109
	ndwidth Product (2) VCE = 10 Vdc, fTest = 10 f	MHz)	gris ighi. T	fTorray	30		MHz
	c, IE = 0, f = 100 kHz)	on handled to value	1180 1180	Cob	286190 #8182	300	pF
(V <sub>BE</sub> = 2.0 Vd	ce Ic, I <sub>C</sub> = 0, f = 100 kHz)	THE PARTY NEW YORK	0.000	· C <sub>ib</sub>	28 38	1250	0.8 PF
WITCHING CHA	ARACTERISTICS			VOLTE	BRATION AS	TTIME RETORAGE	VOE:
Delay Time Rise Time	(V <sub>CC</sub> = 40 Vdc, V <sub>BE</sub> (off)			t <sub>d</sub>	-	100	ns
Storage Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 I <sub>B1</sub> = I <sub>B2</sub> = 0.2 Adc)	Adc,		t <sub>s</sub>	_	2.0	μs
r and 1 lime	B1 'B2 0.2 7.007	E SERVICE STATE		14	SALES MATERIAL	200	ns

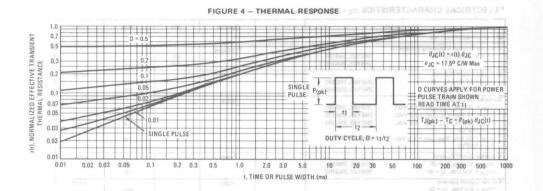
\*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%
(2) f<sub>T</sub> = | h<sub>fe</sub>| · f<sub>Test</sub>



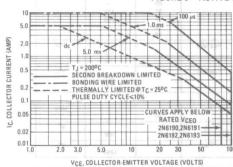








#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $1_{\rm C} - {\rm VCE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 200^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



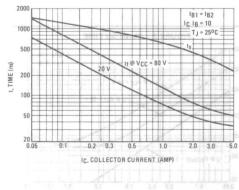
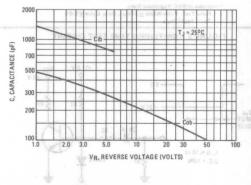


FIGURE 7 - CAPACITANCE versus VOLTAGE



MEDIUM-POWER HIGH-VOLTAGE PNP POWER TRANSISTORS

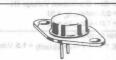
... designed for high-speed switching and linear amplifier applications for high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

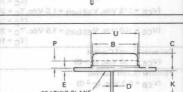
- Collector-Emitter Sustaining Voltage VCEO(sus) = 225 to 350 Vdc @ IC = 200 mAdc
- Second Breakdown Collector Current I<sub>S</sub>/b = 875 mAdc @ V<sub>CE</sub> = 40 Vdc
- t<sub>f</sub> = 0.6 μs Resistive Fall Time
- Usable DC Current Gain to 2.0 Adc

#### 2 AMPERE

# POWER TRANSISTORS PNP SILICON

225-350 VOLTS 35 WATTS





SEATING PLANE

STYLE 1:
PIN 1: BASE
2. EMITTER
CASE: COLLECTOR

	MILLI	METERS	IN	CHES
MIC	MIN	MAX	MIN	MAX
В	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	- The	0.360	1.745
P	-	1.27	-	0.050
0	3.61	3.86	0.142	0.152
S	CHTS	8.89	BAH	0.350
T	-	3.68	-1	0.145
U	-	15.75	-1	0.620

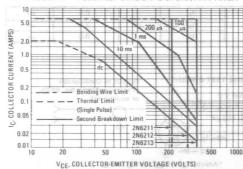
All JEDEC Dimensions and and Notes Apply. CASE 80-02 TO-66

*MAXIMUM RATINGS					uris .
Rating a.o	Symbol	2N6211	2N6212	2N6213	Unit
Collector-Emitter Voltage	VCEO	225	300	350	Vdc
Collector-Base Voltage	VCB	275	350	400	Vdc
Emitter-Base Voltage	VEB	<b>₹</b> 290	— 6 —	-	Vdc
Collector Current — Continuous Peak	lc	-	2 5	16212	Adc
Base Current	IB	4	1	01500	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	12001-1717	— 35 — — 0.2 —	1158)	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +20	00 515.89	° °C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	5.0	°C/W

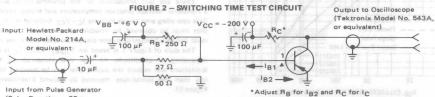
FIGURE 1 - FORWARD BIAS SAFE OPERATING AREA



There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J[pk]} = 200$ ;  $T_C$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See Figure 8).

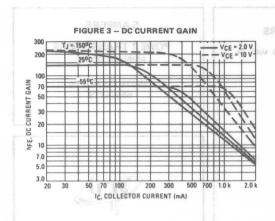
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N6211 2N6212 2N6213	VCEO(sus)	225 300 350		Vdc
*Collector France Contribute Voltage	2140213	V	350		Vdc
*Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, V <sub>BE</sub> = -1.5 V, L = 10 mH)	2N6211 2N6212 2N6213	VCEX(sus)	275 350 400	MEDIUM-P Nyp Pol	Vac
*Collector-Emitter Sustaining Voltage (1) ( $I_C = 200 \text{ mA}$ , $I_B = 0$ , $R_{BE} = 50 \Omega$ )	2N6211 2N6212 2N6213	VCER(sus)	250 325 375	id for high-speed stage operations rs, defigation sa	obV <sub>sign</sub>
*Emitter-Base Breakdown Voltage (1)	1	VEBO	whe Weekle	could be able to	Vdc
(I <sub>E</sub> = 0.5 mAdc, I <sub>C</sub> = 0) (I <sub>E</sub> = 1.0 mAdc, I <sub>C</sub> = 0)	2N6212/13 2N6211	10 = 200 mAdi	6.0 6.0	or-Emitter Stistal O(sus) = 225 to	FOV
*Collector Cutoff Current		ICEV	setor Curre	Breakdown Col	mAdc
$(V_{CE} = 250 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_{C} = 25)$ $(T_{C} = 100)$	o°C)	ala	GE - 40 V	0.5 5.0	idhal aa a
(V <sub>CE</sub> = 315 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 25			D#1311	0.5	2.12 - 1, 10
(T <sub>C</sub> = 10 (V <sub>CE</sub> = 360 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 25 (T <sub>C</sub> = 10	°C)		10-2.0 Ade	5.0 0.5 5.0	eldeaU #
Collector Cutoff Current (V <sub>CE</sub> = 150 Vdc, I <sub>B</sub> = 0)	All Types	ICEO	-	5.0	mAdc
*Emitter Cutoff Current		IEBO		80 MITA	mAdc
(VEB = 6.0 Vdc, IC = 0)	2N6211 2N6212 2N6213	al zhegit zh	System 1	1.0 0.5	q
*ON CHARACTERISTICS (1)	56V 005 081	982	B2Y 7	9001	NAT AND DUMBE
200	gbV agent B	h-2	83× 1	Nga.ri	O V DUNG THE
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.8 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 3.2 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	2N6211 2N6212 2N6213	hFE	10 10 10	100 100 100	der Corrent
Collector-Emitter Saturation Voltage	Level 27 Level 27 Total	VCE(sat)		Pag = oT @ notice	Vdc
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 125 mAdc)	2N6211		4	1.4	
	2N6212 2N6213	39- n	rar	1.6	tide and Sta
Base-Emitter Saturation Voltage	All Types	V <sub>BE</sub> (sat)	1 - 2 -	1.4	Vdc
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 125 mAdc)  DYNAMIC CHARACTERISTICS			- 6	ARACTERISTIC	KO JARIN
*Current Gain—Bandwidth Product (2) (IC = 200 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 5.0 MH	NASO CAM	OL TT	20	Characteristics a, Junetion to Cas	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0		Cob	-	220	pF
*SECOND BREAKDOWN	below and the same				
*Second Breakdown Collector Current with Base Fo t = 1.0 s (non-repetitive) (V <sub>CE</sub> = 40 Vdc)	rward Biased	I <sub>S/b</sub>	0.875	_	Adc
*SWITCHING CHARACTERISTICS	A)III	NA SWITARSON	STACENIO	MITATERUT - 7 S	ansi.
Rise Time	1 10 Ada	t <sub>r</sub>	1 + 1	0.6	μs
Storage Time (V <sub>CC</sub> = 200 Vdc		t <sub>s</sub>	-7	2.5	μs
Fall Time I <sub>B1</sub> = I <sub>B2</sub> = 0.12	o Adc)	tf		0.6	μs

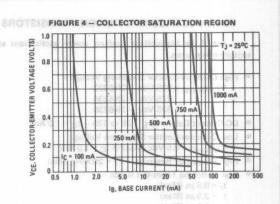


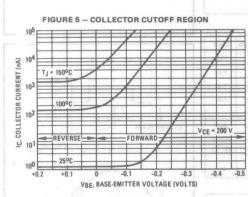
(Pulse Duration = 20 µs. Rep. Rate = 200 Hz)

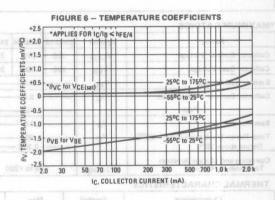
Al<sub>B1</sub> and I<sub>B2</sub> measured with Tektronix Current Probe P6019 and Type 134 Amplifier, or equivalent

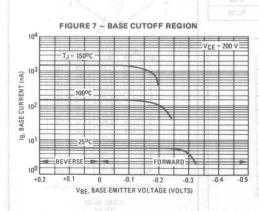


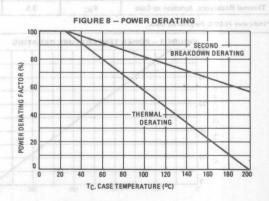














#### HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . useful for high-voltage medium power applications such as switching regulators.

 High Collector-Emitter Sustaining Voltage — VCEO(sus) = 225 Vdc — 2N6233

275 Vdc - 2N6234 325 Vdc - 2N6235

- DC Current Gain hFE = 25 to 125 IC = 1.0 Adc
- Low Collector-Emitter Saturation Voltage
   VCE(sat) = 0.5 Vdc (Max) @ IC = 1.0 Adc
- High Frequency Response fT = 20 MHz (Min)
- Fast Switching Times @ 1.0 Adc 3.0 Adc

 $t_r = 0.5 \,\mu s \,(Max)$ 

 $t_S = 3.5 \,\mu s \,(Max)$ 

 $t_f = 0.5 \,\mu s \,(Max)$ 

#### 5 AMPERE

POWER TRANSISTORS
NPN SILICON

225,275,325 VOLTS 50 WATTS



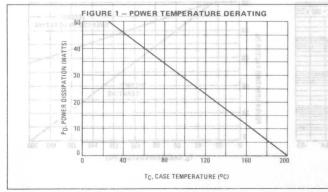
#### \*MAXIMUM RATINGS

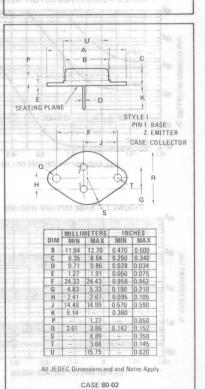
	11 18 18 18				
Rating	Symbol	2N6233	2N6234	2N6235	Unit
Collector-Emitter Voltage	VCEO	225	275	325	Vdc
Collector-Base Voltage	VCB	250	300	350	Vdc
Emitter-Base Voltage	VEB	V tar suur	- 6.0 <del>-</del>	-	Vdc
Collector Current — Continuous  Peak	1c		- 5.0 - - 10 -		Adc
Base Current  Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	I <sub>B</sub>	V 101 SIVE	- 2.0 - - 50 - - 0.286 -		Adc Watts W/OC
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	00 1	65 to +20	00	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	3.5	°C/W

\*Indicates JEDEC Registered Data.





#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
FF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (1 <sub>C</sub> = 20 mAdc, 1 <sub>B</sub> = 0)	2N6233 2N6234 2N6235	VCEO(sus)	225 275 325		Vdc
Collector Cutoff Current (VCE = 225, I <sub>B</sub> = 0) (VCE = 275, I <sub>B</sub> = 0) (VCE = 325, I <sub>B</sub> = 0)	2N6233 2N6234 2N6235	ICEO		1.0 1.0 1.0	mAdo
Collector Cutoff Current (VCE = 250 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C) (VCE = 300 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N6233 2N6234	ICEX	-	1.0	mAdc
(V <sub>CE</sub> = 350 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N6235			1.0 52.00 3.00 AG	
Collector Cutoff Current (V <sub>CB</sub> = 250 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 300 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 350 Vdc, I <sub>E</sub> = 0)	2N6233 2N6234 2N6235	СВО	93 - 30	0.1 0.1 0.1	mAdo
(V <sub>CB</sub> = 350 Vdc, I <sub>E</sub> = 0)  Emitter Cutoff Current (V <sub>BE</sub> = 6.0 Vdc, I <sub>C</sub> = 0)	2N6235 18-4 (sm) 3MIT 3	I <sub>EBO</sub>	9.1 - 2.0	0.1	mAdo

#### ON CHARACTERISTICS (1

DC Current Gain	hFE ABRA OM	25 25 10	125 -	VITOA –
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)	VCE(sat)		0.5	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)	V <sub>BE</sub> (sat)	A= X	1.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	V <sub>BE</sub> (on)	1/2/	BREAKDOWN*	Vdc

#### DYNAMIC CHARACTERISTICS

Current-Gain Eandwidth Product (2)	fŢ			MHz
(I <sub>C</sub> = 0.25 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)		20	e garrero yazi	ANTHER TOTAL
Output Capacitance of applies like another coll Izament	Cob	286234	250	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)		208235 L-	250	S. house S.

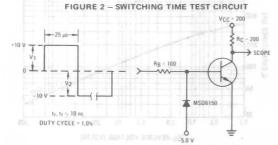
#### SWITCHING CHARACTERISTICS

Rise Time $(V_{CC} = 200 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc})$	tr	ALTHON SONT HO	0.5	μs
Storage Time $(V_{CC} = 200 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = I_{B2} = 0.1 \text{ Adc})$	t <sub>S</sub>	-	3.5	μs
Fall Time (V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> = 1.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.1 Adc)	tf	-	0.5	μs

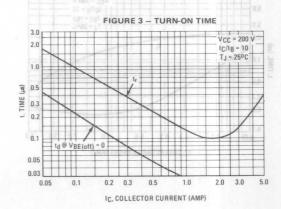
\*Indicates JEDEC Registered Data.

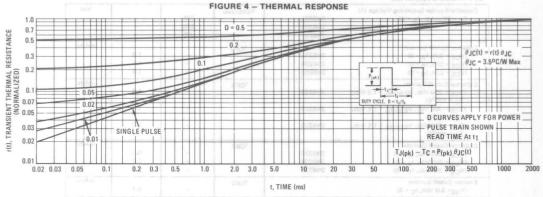
(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

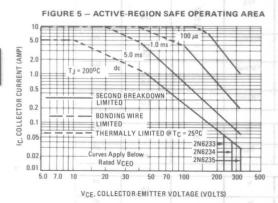
#### 1 16 1031



FOR INFORMATION ON FIGURES 3 and 6 RB AND RC ARE VARIED TO OBTAIN DESIRED CURRENT LEVEL.; D1 DISCONNECTED AND V2 REDUCED TO 5 VOLTS FOR 1d MEASUREMENT.

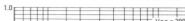






There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indi-

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



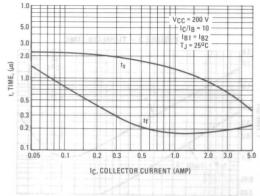
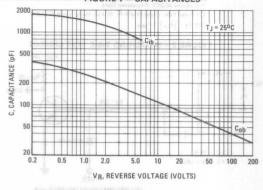


FIGURE 6 - TURN-OFF TIME

#### FIGURE 7 - CAPACITANCES





#### HIGH VOLTAGE NPN SILICON POWER **TRANSISTORS**

. . . designed for high voltage inverters, switching regulators and line operated amplifier applications. Especially well suited for switching power supply applications.

- High Voltage Breakdown Rating
- Low Saturation Voltages
- Fast Switching Capability
- · High ES/b Energy Handling Capability

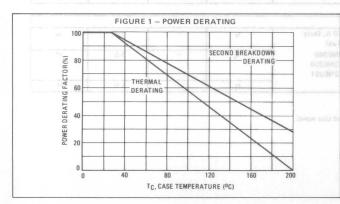
#### MAXIMUM RATINGS

Rating	Symbol	2N6249	2N6250	2N6251	Unit
*Collector-Emitter Voltage U. 8	VCEO(sus)	200	275	350	Vdc
*Collector-Emitter Voltage 0.7	VCER(sus)	225	300	375	Vdc
*Collector-Base Voltage	V <sub>CB</sub>	300	375	450	Vdc
Emitter-Base Voltage	VEB	4	<del></del> 6.0	-	Vdc
Collector Current — Continuous** — Peak	I <sub>C</sub>		— 15 — — 30 —	N CD	Adc
Base Current — Continuous* — Peak	I <sub>B</sub>	4	— 10 — — 20 —		Adc
Emitter Current — Continuous — Peak	I <sub>E</sub> M	-	— 25 — — 50 —	and the second second	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C^*$	PD 01 0.8 0.0		— 175 — — 100 — — 1.0 —		Watts W/°C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	65 to +200	)——	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	IL	275	°C 040

- \*Indicates JEDEC Registered Data.
- \*\*JEDEC Registered Value is 10 A, Motorola Guaranteed Value is 15 A.

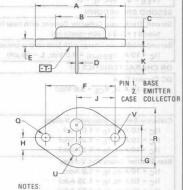


## 15 AMPERE

#### **POWER TRANSISTORS** NPN SILICON

200, 275, 350 VOLTS 175 WATTS - 005 - 31





- 1. DIMENSIONS Q AND V ARE DATUMS.
- 2. T. IS SEATING PLANE AND DATUM. 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
  - ♦ 0.13 (0.005) M T V M

#### FOR LEADS:

♦ 0.13 (0.005) M T VM QM 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIMETERS		INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	181	39.37	-	1.550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F.	30.15	BSC	1.187 BSC		
G	10.92	BSC	0,430 BSC		
Н	5.46	BSC	0.215 BSC		
J	16.89	BSC	0.665 BSC		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

**CASE 1-05** 

	Characteristic			Symbol	Min.	Max	Unit	1
OFF CHARACTERISTI	cs			9	COTSISIA	AGY		-
Collector-Emitter Sustain				VCEO(sus)	1	T	Vdc	7
$(I_C = 200 \text{ mA}, I_B = 0)$		2N6249	nil bne si	vitching regulate		t for high voltage	empisab	
LICON		2N6250 mmb hwe 2 2N6251		y well suited for	275 350	plifier application v apolications	operated an	
Collector-Emitter Sustain	ning Voltage (Table 1)			VCER(sus)			Vdc	1
(I <sub>C</sub> = 200 mA)		2N6249			225	age Breakdown R	loV rigit Vol	-
		2N6250 2N6251			300 375	ration Voltager	a Low San	
Collector Cutoff Current				ICEV		Ching Capabin y	mAdc	1
	, VBE(off) = 1.5 Vdc) , VBE(off) = 1.5 Vdc, T <sub>C</sub>	= 125°C)			Capability	gnilbnsH 5.0 end a 10	SE day a	
Collector Cutoff Current				ICEO		384	mAdc	XA
(VCE = 150 Vdc, IB		2N6249		s foesaws leas	entand 200	5.0	nite R	1
(V <sub>CE</sub> = 225 Vdc, I <sub>B</sub> (V <sub>CE</sub> = 300 Vdc, I <sub>B</sub>		2N6250 2N6251		30 274	(unios	0.0	otor Frontee V	lio'
Emitter Cutoff Current		JabV	378	1EBO 85	(atte) 83	THE RESERVED	mAdc	ollo
(VEB = 6.0 Vdc, IC =	0)			3/5	2000	100	arloV essi notes	10
SECOND BREAKDOWN	I .	Vide		0.0	ggV		ages lo Visage H	orie
	ector Current with base fo			IS/b	5.8	**auounimo	Vdc vor	B
biased t = 1.0 s (non-			E = 100 V)		0.3	- Alax	1-	1
	gy with base reverse biased $= 4.0 \text{ Vdc}, L = 50 \mu\text{H}$	(Table 1)	-	ES/b	2.5	- 520001	James Limit Conti	) log
ON CHARACTERISTIC	S (1)	Pide		25	- ai	tionania	Our ent - Co	grie
C Current Gain				hFE	- MR	N.	99 198	
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> =	3.0 Vdc)	2N6249 2N6250		178	10 8.0		Power Dissipation	aj
		2N6250		001	6.0	50 50 50 50 50 50 50 50 50 50 50 50 50 5	Pare spoke 25°C	-
Collector-Emitter Satura	tion Voltage	30	-	VCE(sat)	nee gar	T notional s	Vdc Vdc	100
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.		2N6249			1 -	1.5	מוקמר זיטרפ ולשחק	oT.
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1. (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.		2N6250 2N6251			_	23:52IAST	MARAHD JAMI	F 31
Base-Emitter Saturation		2.10201	sterio -	VBE(sat)	lodmy0	1.5	Vdc	-
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.		2N6249		0.000	De.ic.	9660 2.5 oitone	nal P. sistance, .	
$(I_C = 10 \text{ Adc}, I_B = 1.$		2N6250		575	JT.	2.5	gmail beat must	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.	DV TV GARDARDARDARD A	2N6251			_	2.5	Ider) ng Pur sasa	1
DYNAMIC CHARACTE		-			T	solstered Days	E 752752	7
Current-Gain - Bandwid	th Product 10 Vdc, f <sub>test</sub> = 1.0 MHz)			fT A 31 ei aulsV b	2.5		baretsine 8 030	
SWITCHING CHARACT	Maria Caralla			1 1 1 1 1 1 1 1 1			paratrig. 1 5 44	1
Resistive Load (Table 1)	2017.7 407	1		DIFFA	REPORTED BER	- ranuois		7
Rise Time	(V <sub>CC</sub> = 200 Vdc, I <sub>C</sub> Cycle ≤ 2.0%, t <sub>p</sub> =	c = 10 A, Du	ty	tr	1-1	2.0	μς μς	1
Storage Time	(I <sub>B1</sub> = I <sub>B2</sub> = 1.0 Ac			FROM A STEE CHILLIS	-	3.5	μs	1
VA   M188   28	(I <sub>B1</sub> = I <sub>B2</sub> = 1.25 A (I <sub>B1</sub> = I <sub>B2</sub> = 1.67 A	(dc) 2N6250		WITA930			10F 85	1
all Time	15 8			tf	1	1.0	μs	1
700.0 840.0 RO	1 100 0				1		2	
<ul> <li>Indicates JEDEC Reg</li> <li>Measured on a curve</li> </ul>	istered Data. tracer (60 Hz full-wave red	ctified sine w	ave).					
			partie.		-		7 5	
		1.4						

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

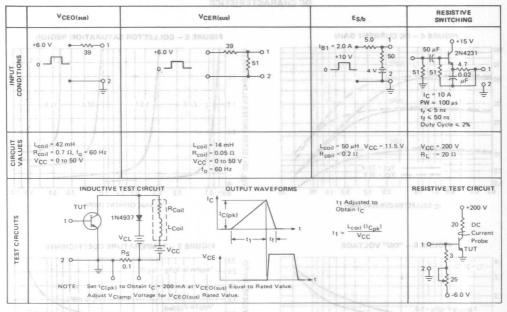


FIGURE 2 - THERMAL RESPONSE

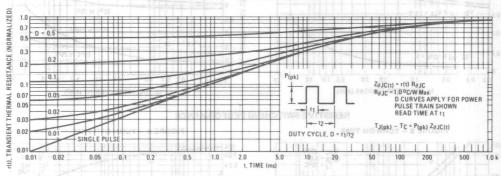
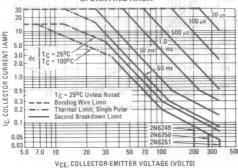


FIGURE 3 - ACTIVE-REGION SAFE OPERATING AREA

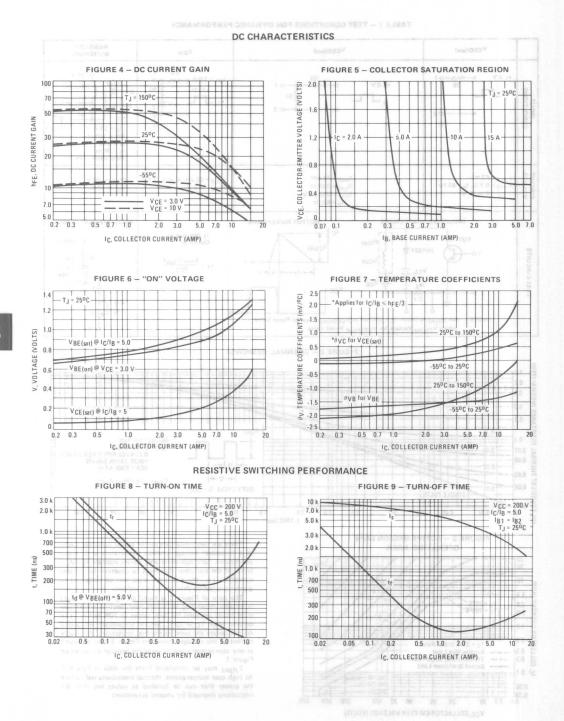


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on T<sub>C</sub> = 25°C, T<sub>J</sub>(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 3 may be found at any case temperature by using the appropriate curve on

T<sub>J(pk)</sub> may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





#### HIGH-POWER NPN SILICON TRANSISTORS

... designed for use in industrial-military power amplifer and switching circuit applications.

• High Collector Emitter Sustaining Voltage -VCEO(sus) = 100 Vdc (Min) - 2N6274

= 120 Vdc (Min) - 2N6275 = 140 Vdc (Min) - 2N6276

= 150 Vdc (Min) - 2N6277

· High DC Current Gain -

hFE = 30-120 @ IC = 20 Adc

= 10 (Min) @ IC = 50 Adc

 Low Collector-Emitter Saturation Voltage — VCE(sat) = 1.0 Vdc (Max) @ IC = 20 Adc

• Fast Switching Times @ IC = 20 Adc

 $t_r = 0.35 \,\mu s \,(Max)$ 

 $t_s = 0.8 \,\mu s$  (Max

 $t_f = 0.25 \,\mu s \,(Max)$ 

Complement to 2N6377-79

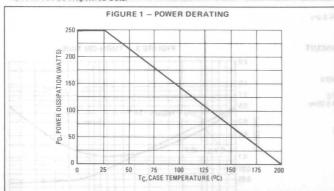
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6274	2N6275	2N6276	2N6277	Unit
Collector-Base Voltage	VCB	120	140	160	180	Vdc
Collector-Emitter Voltage	VCEO	100	120	140	150	Vdc
Emitter-Base Voltage	VEB	-	6	.0 —	-	Vdc
Collector Current – Continuous Peak	IC-	- 10		00		Adc
Base Current	IB	-	2	20 —	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	(10)-	-	50 —— 43——	<u></u>	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-		0 +200—	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	0.7	°C/W

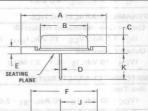
\*Indicates JEDEC Registered Data.

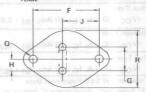


#### 50 AMPERE POWER TRANSISTORS NPN SILICON

100, 120, 140, 150 VOLTS 250 WATTS







STYLE 1: PIN 1. BASE 2. EMITTER
CASE. COLLECTOR

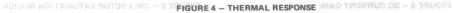
	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

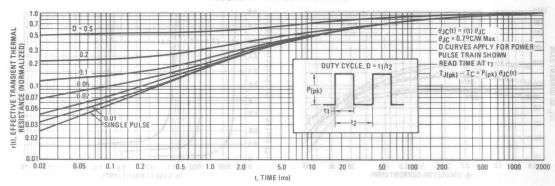
CASE 197-01

## 2N6274 thru 2N6277

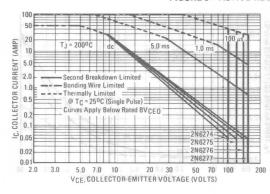
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS				100 Total 10 To	. K.
Collector-Emitter Sustaining Voltage (1)		V <sub>CEO(sus)</sub>			Vdc
(I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	2N6274	020(303)	100	_	
	2N6275		120		
	2N6276	CON TRANSI	140 150	GH-POWER	
0.11	2N6277		150		
Collector Cutoff Current	CAR STRIGME S	ICEO	200111	50	μAdc
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	2N6274			1	
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	2N6275	The second secon		im 3 150 191 0	rgiff w
(V <sub>CE</sub> = 70 Vdc, I <sub>B</sub> = 0)	2N6276	- 2848274		60 00	
(V <sub>CE</sub> = 75 Vdc, I <sub>B</sub> = 0)	2N6277	2146275	- (mild+obV	-	
Collector Cutoff Current		ICEX	Vide (Mun)	141=	
$(V_{CE} = Rated V_{CB}, V_{EB(off)} = 1.5 Vdc)$		21/6277	Vdc 4Min) +	10	μAdc
$(V_{CE} = Rated V_{CB}, V_{EB(off)} = 1.5 Vdc, T_{C} =$	150 <sup>o</sup> C)		(1)	6 CO.1901 6	mAdc
Emitter Cutoff Current		IEBO	IC - 20 Add		μAdc
(VBE = 6.0 Vdc, IC = 0)		ab.	A 08 = 51 9	(h) (d) 01 =	
ON CHARACTERISTICS (1)		- spatioV r	er Satutation	dime terret	) - 15 °
DC Current Gain	<del> </del>		de (Max) et	V 0	9(-
(IC = 1.0 Adc, VCE = 4.0 Vdc)		hFE ob/	00 50 0 8	witch <u>ing</u> Time	■ Fals
(I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 4.0 Vdc)			30	120	
(I <sub>C</sub> = 50 Adc, V <sub>CE</sub> = 4.0 Vdc)			10	хьМ) гц 8.0	
			10	Nath) en 25.0	17
Collector-Emitter Saturation Voltage		VCE(sat)	00.500	MS 0110 2NI	Vdc
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2/0 Adc)					
(I <sub>C</sub> = 50 Adc, I <sub>B</sub> = 10 Adc)			-	3.0	A SHARIX
Base-Emitter Saturation Voltage		VBE(sat)			Vdc
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2.0 Adc)	RN6876 SN6277 Unit	3129NS 2782NS	Jodeny2	1.8	
(I <sub>C</sub> - 50 Adc, I <sub>B</sub> - 10 Adc)	180 180 Vet	120 146	_ao√=	3.5 000.1	ov -seit-tora
Base-Emitter On Voltage		VBE(on)	Vesa	1.8	Vdc
(I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 4.0 Vdc)	Laby C	2	and l	100	in' modern
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product (2)		or f <sub>T</sub>	30	Pope	MHz
(IC - 1.0 Adc, VCE - 10 Vdc, f <sub>test</sub> - 10 MHz)		VC	wit I		
Output Capacitance		Cob	6 100	600	pF
(V <sub>CB</sub> - 10 Vdc, I <sub>E</sub> = 0, f 0.1 MHz)	100%		0, 1,	200 July 200 B	
SWITCHING CHARACTERISTICS			7.7	Activity (Line)	12 - 32 00130
Rise Time		tr	Bis and	0.35	μs
(VCC = 80 Vdc, IC = 20 Adc, IB1 - 2.0 Adc, V	BE(off) 5.0 Vdc)		831	ARACTERIST	
Storage Time	y	t <sub>s</sub>	0.01	0.80	μs
(VCC = 80 Vdc, IC - 20 Adc, IB1 - IB2 - 2.0 A	ide) sint/ xelf	Symbol		993201	
Fall Time	Who Fo	out <sub>f</sub>	- 000	0.25	us lan
(VCC 80 Vdc, IC = 20 Adc, IB1 = IB2 = 2.0 A		- North			27
*Indicates JEDEC Registered Data.	par			ALL SHARE STATE OF THE STATE OF	
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycl	e ≤2.0%.	R DERATING			
(2) f <sub>T</sub> h <sub>fe</sub> • f <sub>test</sub> .					
FIGURE COMP.	CIDCIUT		FIGURES	TUDAL ON TIM	
	CINCUIT		FIGURE 3 -	TURN-ON TIM	E .
FIGURE 2 - SWITCHING TIME TEST	2				A.K.
	2	.0			
X - 170 - 273 738 1 3 6 1 10 11 1	C 2+80 V			Ic/li	3 = 10
2   50 cm   2F3 V Sect J Me   2 cm   1 cm   2 cm	P+80 V 1.	0			B = 10 J = 25°C
2   50 cm   2F3 V Sect J Me   2 cm   1 cm   2 cm	R <sub>C</sub> 0	0 .7			
2   50 cm   2F3 V Sect J Me   2 cm   1 cm   2 cm	RC 0 4.0 Ohms 0	0 .7 .5	V <sub>BE(off)</sub> = 5.0 V		
	RC 0 4.0 Ohms 0	0 .7 .5	VBE(off) = 5.0 V		
30 μs - 10 0 hms - 10 0 hms	RC 0 4.0 Ohms 0	0 .7 .5	VBE(off) = 5.0 V		
30 μs +21.5 V 0 0 0 ms	CC +80 V 1. RC 0 4.0 Ohms 0 3 3 W 1. C	0 7 7 5 5 3 2 tr @ V CC = 80 V	V <sub>BE</sub> (off) = 5.0 V		
30 μs +21.5 V 10 0hms 0 -18.5 V 1N3879	RC 0 4.0 Ohms 0	0 7 7 5 5 3 2 tr @ V CC = 80 V	VBE(off) = 5.0 V		
30 μs +21.5 V 0 0 0 ms	C	0 7.7 5.5 5.3 3.2 1.1 1.7 1.7 1.7 1.7 1.7 1.7 1.7 1.7 1.7	V <sub>BE</sub> (off) = 5.0 V		
30 μs +21.5 V R <sub>B</sub> 10 0 hms 1 1N3879	CC +80 V 1. RC 0. 4.0 Ohms 0. WH.	0 7.7 5.5 5.3 3.2 1.1 1.7 1.7 1.7 1.7 1.7 1.7 1.7 1.7 1.7	VBE(off) = 5.0 V		
30 $\mu$ s +21.5 $V$ 18.5 $V$ 10 0hm 10 0hms 0uty Cycle = 0.5%	CC +80 V 1. RC 0. 4.0 Ohms 0. W 0. L 0. C	0 7.7 5.5 3.3 2.2 1, r @ V CC = 80 V	VBE(off) = 5.0 V		

IC, COLLECTOR CURRENT (AMP)





ELANGHIBBOD BAUTARBUM FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA V WO" - 01 BRUDIA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on  $T_{J(pk)}=200^0\mathrm{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 200^0\mathrm{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 6 - TURN-OFF TIME

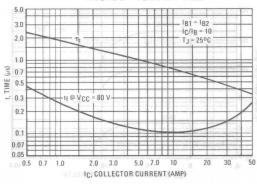
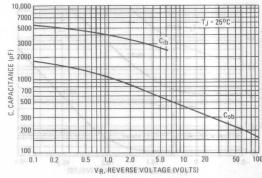
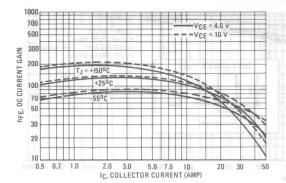
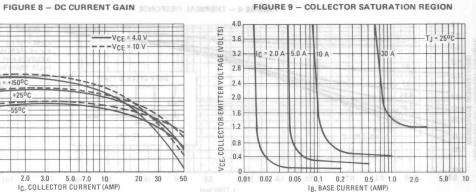


FIGURE 7 - CAPACITANCE







20 30

2.0 VOLTAGE (VOLTS) VBE @ VCE = 4.0 V VCE(sat) 0.4 @ IC/IB = 10 0.5 0.7 1.0 2.0 5.0 7.0 10

FIGURE 10 - "ON" VOLTAGES TARGED STAR MODELS FIGURE 11 - TEMPERATURE COEFFICIENTS

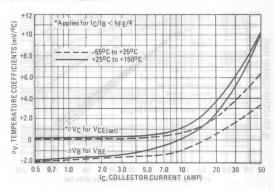


FIGURE 12 - COLLECTOR CUT-OFF REGION

IC, COLLECTOR CURRENT (AMP)

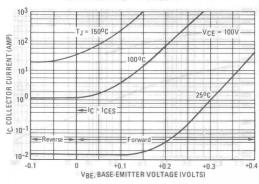
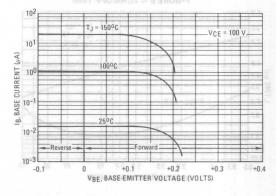


FIGURE 13 - BASE CUT-OFF REGION



0.5 0.7 1.0

\*ELECTRIC . L CHARACTERISTICS (To = 25°C unless otherwise noted)



#### DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and low-frequency switching

- High DC Current Gain @ IC = 10 Adc hFE = 2400 (Typ) - 2N6282, 2N6283, 2N6284 = 4000 (Typ) - 2N6285, 2N6286, 2N6287
- Collector-Emitter Sustaining Voltage —

VCEO(sus) = 60 Vdc (Min) - 2N6282, 2N6285 = 80 Vdc (Min) - 2N6283, 2N6286 = 100 Vdc (Min) - 2N6284, 2N6287

 Monolithic Construction with Built-In Base-Emitter Shunt Resistors

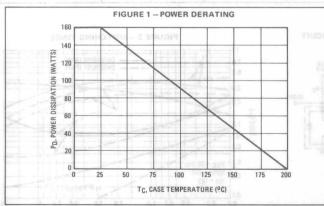
#### \*MAXIMUM RATINGS

Rating 007	Symbol	2N6282 2N6285	2N6283 2N6286	2N6284 2N6287	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	5.0			Vdc
Collector Current – Continuous Peak	lc		20 40		Adc
Base Current	1 <sub>B</sub>	V	0.5		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	160 0.915			Watts W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +20	0	°C

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.09	°C/W

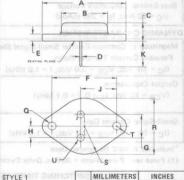
<sup>\*</sup>Indicates JEDEC Registered Data.



#### DARLINGTON 20 AMPERE COMPLEMENTARY SILICON **POWER TRANSISTORS**

60, 80, 100 VOLTS 160 WATTS





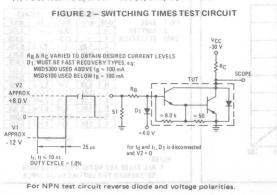
YLE 1		This:	MILLIN	METERS	INC	HES
PIN 1.	BASE	DIM	MIN	MAX	MIN	MAX
2.	EMITTER	Α	-	39.37	-	1,550
CASE	COLLECTOR	В	-	21.08	-	0.830
		C	6.35	7.62	0.250	0.300
		D	0.97	1.09	0.038	0.043
		E	1.40	1.78	0.055	0.070
		F	29.90	30.40	1.177	1.197
		G	10.67	11.18	0.420	0.440
	7	Н	5.33	5.59	0.210	0.220
		J	16.64	17.15	0.655	0.675
		K	11.18	12.19	0.440	0.480
		0	3.81	4.19	0.150	0.165
		R	4	26.67	71. to 10.	1.050
		U	2.54	3.05	0.100	0.120

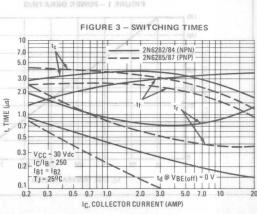
CASE1-04

1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

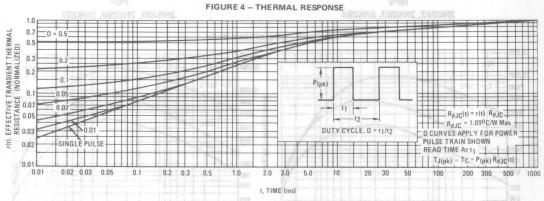
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic			No. of Squares	-	S	mbol	Min	Max	Unit
OFF CHARACTERISTICS			YAATI	43M	319	M COM	LINGTO	BAC	
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	2N6282, 2N6285			EO (sus)	60 80 100	Still  designed for	Vdc		
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	2N6283, 2N6286		dc - N628	6282, 2		on 00.1 Currel in 10.1 2400 0.1 4000	mAdc		
Collector Cutoff Current $(V_{CE} = Rated\ V_{CB}, V_{BE(off)} = 1.5\ Vdc)$ $(V_{CE} = Rated\ V_{CB}, V_{BE(off)} = 1.5\ Vdc, T_{C} = 1$	accaige co-		N62				mAdc		
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		Ing	mitter Sh		B nf	ЕВО	struction w	2.0 onc	mAdc
N CHARACTERISTICS (1)									
DC Current Gain (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 3.0 Vdc)	rinti	2NS234 2NG267	2NATES 2NATES	286	2708	hFE lodmy8	750 100	18,000	MARXAM
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 40 mAdc) (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 200 mAdc)	ativ	100	68	8	Vo	E(sat)	-	2.0 3.0	3-w Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	Audic		20		VE	E(on)	suou	2.8	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 200 mAdc)	Adc		0.5		VE	E(sat)	5020	4.0	Vdc
YNAMIC CHARACTERISTICS	5,956		160			-64	II. JERUS QI	Distribution (a)	Dersio e
Magnitude of Common Emitter Small-Signal Short Forward Current Transfer Ratio ( $I_C = 10$ Adc, $V_{CE} = 3.0 \text{ Vdc}$ , $f = 1.0 \text{ MHz}$ )	-Circuit		85 to +200			h <sub>fe</sub> l .	4.0	-	MHz
Output Capacitance (VCB = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	Unit		2, 83, 84 5, 86, 87		ledn	Cob	ENISTICS	400 600	pF
Small-Signal Current Gain (IC = 10 Adc, VCE = 3.0 Vdc, f = 1.0 kHz)					30	h <sub>fe</sub>	300	EDEC Rugiste	entesioni
*Indicates JEDEC Registered Data. (1) Pulse test: Pulse Width = 300 µs, Duty Cycle =	2%		DI	HTAS	1907	- POWE	FIGURE 1		

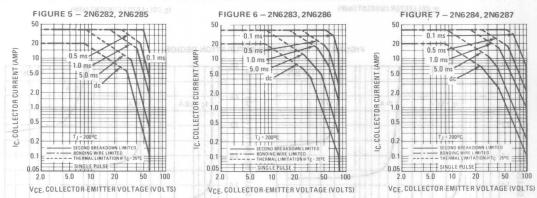




3

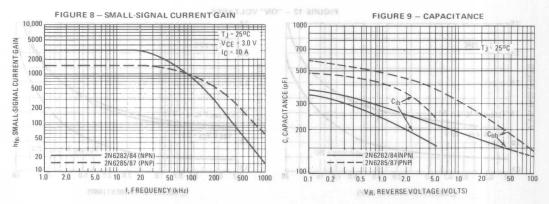


#### **ACTIVE-REGION SAFE OPERATING AREA**

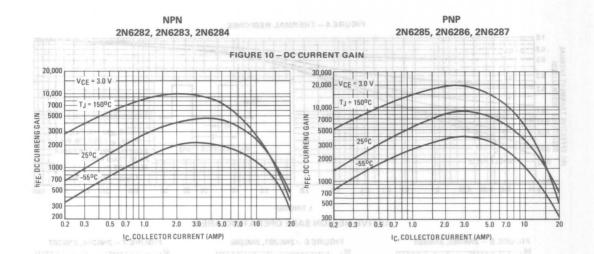


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

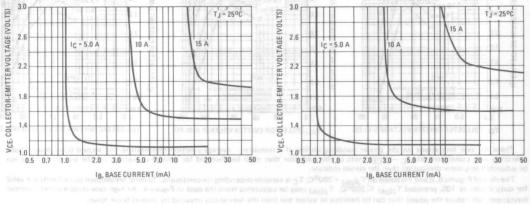
The data of Figures 5, 6 and 7 is based on  $T_{J(pk)} = 200^{\circ}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 200^{\circ}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

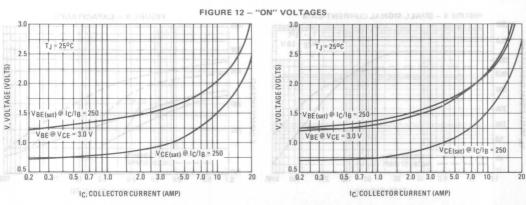








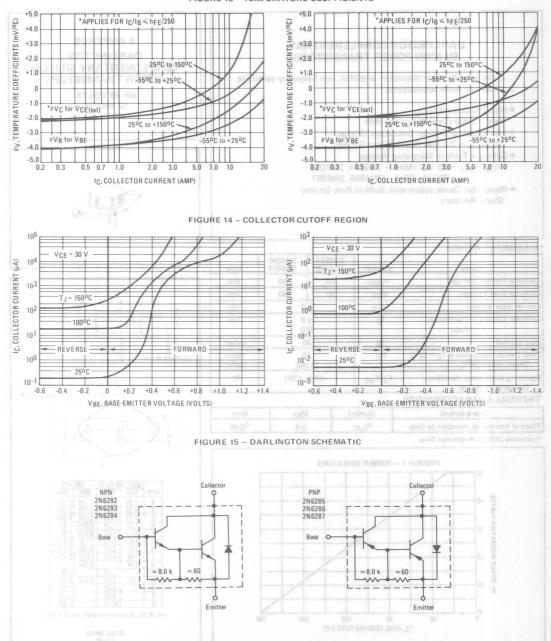




NPN 2N6282, 2N6283, 2N6284

PNP 2N6285, 2N6286, 2N6287





2



DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general-purpose amplifier, low-frequency switching and hammer driver applications.

- High DC Current Gain –
   hFE = 3000 (Typ) @ IC = 2.0 Adc
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 2.0 Vdc (Max) @ IC = 2.0 Adc
- Collector-Emitter Sustaining Voltage
   VCEO(sus) = 60 Vdc (Min) 2N6294, 2N6296
   = 80 Vdc (Min) 2N6295, 2N6297
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

# 4 AMPERES DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

60, 80 VOLTS 50 WATTS



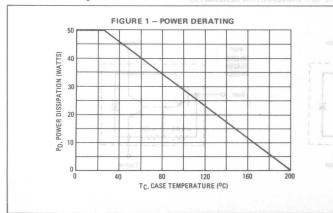
\*MAXIMUM BATINGS

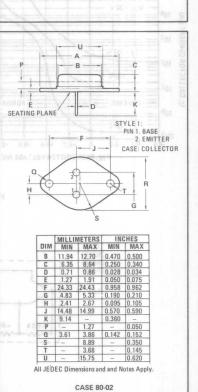
INIAXIIVIOIVI NATTINGS		200 - 220		1.01
Rating	Symbol	2N6294 2N6296	2N6295 2N6297	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	V <sub>CB</sub>	60	80	Vdc
Emitter-Base Voltage	VEB	9001 5	.0	Vdc
Collector Current — Continuous Peak	1 <sub>C</sub>	4.0 8.0		Adc
Base Current	IB	80		mAdc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	50 0.286		Watts W/ <sup>O</sup> C
Operating and Storage Junction,	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°c

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	3.5	°C/W

\*Indicates JEDEC Registered Data





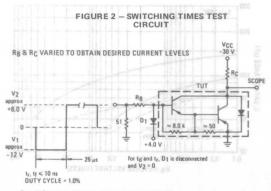
3-214

BUILD THE COLLECTOR CUTORF REGION

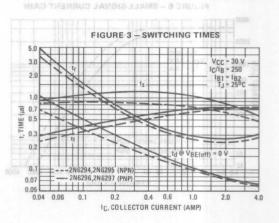
#### \*ELECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted)

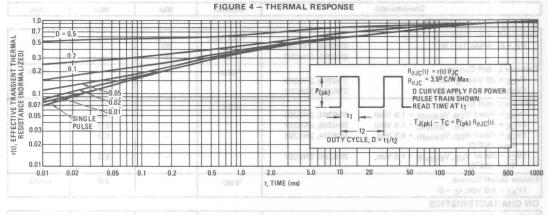
Characteristic	THERMAL RESPONSE	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		TOTAL			E 30.1
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	2N6294, 2N6296 2N6295, 2N6297	VCEO(sus)	60 80		Vdc
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	2N6294, 2N6296 2N6295, 2N6297	ICEO		0.5 0.5	mAdc
Collector Cutoff Current $(V_{CE} = Rated \ V_{CB}, V_{EB}(off) = 1.5 \ Vdc)$ $(V_{CE} = Rated \ V_{CB}, V_{BE}(off) = 1.5 \ Vdc)$ $(V_{CE} = Rated \ V_{CB}, V_{EB}(off) = 1.5 \ Vdc,$ $T_{C} = 150^{\circ}C)$ $(V_{CE} = Rated \ V_{CB}, V_{BE}(off) = 1.5 \ Vdc,$ $T_{C} = 150^{\circ}C)$	2N6294, 2N6295 2N6296, 2N6297 2N6294, 2N6295 2N6296, 2N6297	ICEX	-	0.5 0.5 5.0	mAdc 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	tum) Shift o	IEBO	_	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (IC = 2.0 Adc, VCE = 3.0 Vdc) (IC = 4.0 Adc, VCE = 3.0 Vdc)	GION SAFE OPERATING	hFE 6 - ACTIVE RI	750 100	18000	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 8.0 mAdc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 40 mAdc)	VCE (sat)		2.0 3.0	Vdc	
	transistor: average Safe operating area that must be obse	VBE(sat)	A all	4.0	Vdc
Base-Emitter On Voltage	must not be subjects The data of Fig	VBE(on)	G3TfMi3	38W 2.8 08	Vdc
DYNAMIC CHARACTERISTICS	depending on cond	HAY		(SINCTE LINTRE	
Magnitude of Common Emitter Small-Signal bank mont betalusian Short-Circuit Forward Current Transfer Ratio outstand James (IC = 1.5 Adc, VCE = 3.0 Vdc, f = 1.0 MHz) is said and analysis.		[h <sub>fe</sub> ]	4.0	RATED BY:	80.0 E
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	2N6294, 2N6295 2N6296, 2N6297	Cop (STJO	OS OI OTTER VOLEAGE IV	120	pF <sub>0.1</sub>
Small-Signal Current Gain (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 kHz)		h <sub>fe</sub>	300	-	-

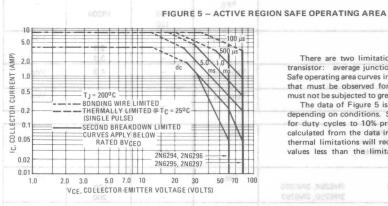
<sup>\*</sup>Indicates JEDEC Registered Data





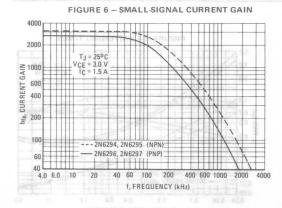


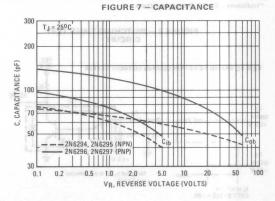




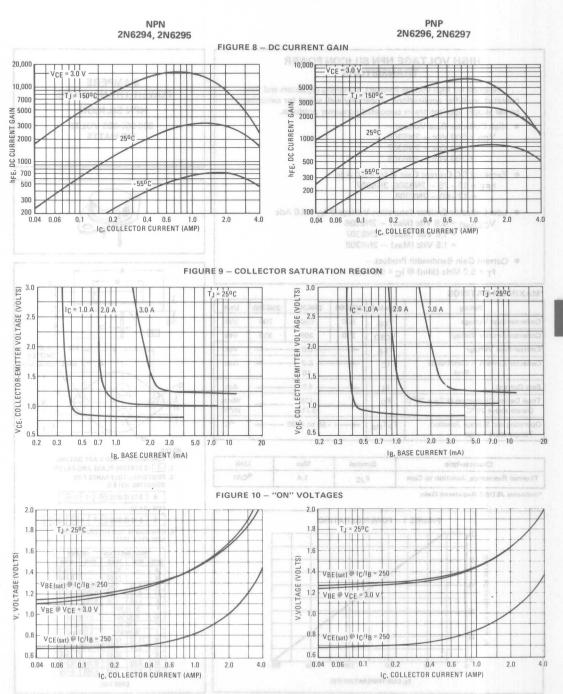
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I  $_{\rm C}-{\rm V}_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_J(pk) = 200$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leqslant 200$ .  $T_J(pk)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





2N6306, 2N6307, 2N6308



. . . designed for high voltage inverters, switching regulators and lineoperated amplifier applications. Especially well suited for switching power supply applications in associated consumer products.

- High Collector-Base Voltage
  - V<sub>CB</sub> = 500 Vdc 2N6306 = 600 Vdc 2N6307

    - = 700 Vdc 2N6308
- Excellent DC Current Gain @ IC = 3.0 Adc
  - hFE = 15 75 2N6306, 2N6307 = 12 -60 2N6308
- Low Collector-Emitter Saturation Voltage @ IC = 3.0 Adc

VCE(sat) = 0.8 Vdc (Max) - 2N6306 = 1.0 Vdc (Max) - 2N6307

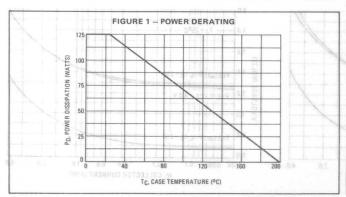
- = 1.5 Vdc (Max) 2N6308
- Current Gain Bandwidth Product fT = 5.0 MHz (Min) @ IC = 0.3 Adc MOITARUTAS MOTOSJJOO - e

\*MANUAL DATINGS

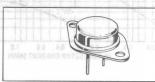
"MAXIMUM RATINGS	134	1 11 1	4 21		0.956 -
Rating ADE	Symbol	2N6306	2N6307	2N6308	Unit
Collector-Base Voltage	VCB	500	600	700	Vdc
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Emitter-Base Voltage	VEB	4	<del></del> 8.0 <del></del>	-	Vdc
Collector Current Continuous Peak	l'c		8.0 — 16		Adc
Base Current	/ I <sub>B</sub>	-	4.0	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4	125 0.714	-	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +200		°C

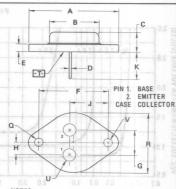
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.4	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data



8 AMPERE **POWER TRANSISTORS** NPN SILICON 250-300-350 VOLTS 125 WATTS





NOTES:

- 1. DIMENSIONS Q AND V ARE DATUMS.
- 2. T- IS SEATING PLANE AND DATUM.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
  - ♦ 0.13 (0.005) M T V M

FOR LEADS:

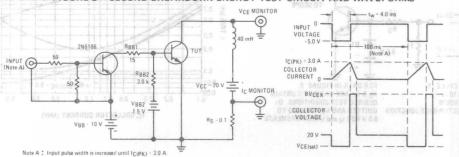
- ♦ 0.13 (0.005) M T VM QM
- 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIN	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
В	-	21.08	- 1	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15	BSC	1,187 BSC		
G	10.92 BSC		0.430 BSC		
H	5.46	BSC	0.215 BSC		
J	16.89	BSC	0.665 BSC		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0,150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
V	3.81	4.19	0.150	0.165	

*FLECTRICAL	CHARACTERISTICS	(Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	2N6306 2N6307 2N6308	VCEO(sus)	250 300 350	-	Vdc
Collector Cutoff Current (VCE = Rated VCEO, IB = 0)	IAL RESPONSE	NEH CEO	uon_	0.5	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 500 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 600 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc)	2N6306 2N6307	CEX		0.5 0.5	mAdc
(V <sub>CE</sub> = 700 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 450 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C) (V <sub>CE</sub> = 550 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc,	2N6308 2N6306 2N6307			0.5 2.5	
T <sub>C</sub> = 150°C) (V <sub>CE</sub> = 650 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N6308			2.5	
Emitter Cutoff Current (V <sub>RE</sub> = 8.0 Vdc, I <sub>C</sub> = 0)		IEBO		1.0	mAdc
ON CHARACTERISTICS				00 14/1	
DC Current Gain (1) (IC = 3.0 Adc, VCE = 5.0 Vdc)	2N6306, 2N6307 2N6308	hFE	15 12	75 60	
(I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	2N6308 2N6306, 2N6307 2N6308	2.0 3.0	4.0 3.0 3.0	E 9 C D	200
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 2.67 Adc)	2N6306 2N6307 2N6308 2N6306, 2N6307 2N6308	VCE(sat)	DA - 5 BAUE	0.8 1.0 1.5 5.0 5.0	Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 2.67 Adc)	2N6306, 2N6307 2N6308	VBE (sat)		2.3 2.5	Vdc
Base-Emitter On Voltage (1) (IC = 3.0 Adc, VCE = 5.0 Vdc) of statement of		V <sub>BE</sub> (on)	11	1.3	Vdc
Second Breakdown Energy (Figure 2) (IC(PK) = 3.0 Adc, L = 40 mH, RBE = 3 kΩ,	V <sub>BB2</sub> = 1.5 Vdc)	E <sub>s/b</sub>	ZEK	180	JaggmJ
DYNAMIC CHARACTERISTICS	midds ag tou senut				
Current Gain — Bandwidth Product (2) (I <sub>C</sub> = 0.3 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MH	es no gnibnequb z)	fτ	5.0	TOTAL THE COMMENT	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)	ottanimii tamadit	Cob	H- national	250	1032 pF
SWITCHING CHARACTERISTICS	Values 1885 Khan		T 2 MARGE E		- pany b
Rise Time (V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc)		002 tr 000	100 200	0.6 0.6	us μs
	c, I <sub>B2</sub> = 1.5 Adc) Ise Width = 25 μs Ise Width = 5.0 μs	t <sub>s</sub>	LIAGE (VOLTS)	0v #3TTM3.#0 1.6 0.8	us
Fall Time (V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 3.0 Adc, I <sub>B1</sub> = 0.6 Add	c, l <sub>B2</sub> = 1.5 Adc)	t <sub>f</sub> TILLO	RIS TEST CIR	MIT 0.4 HOT	WS – SWI

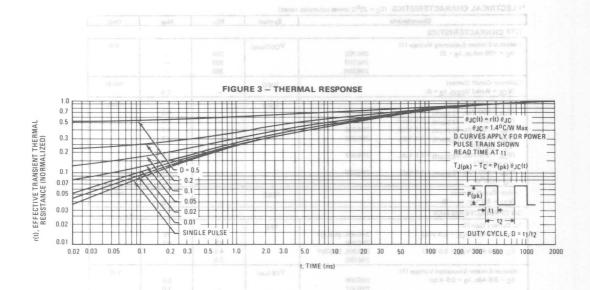
#### FIGURE 2 - SECOND BREAKDOWN ENERGY TEST CIRCUIT AND WAVEFORMS



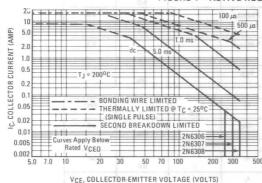
<sup>(1)</sup> Pulse Test: Pulse Width \$300 µs. Duty Cycle = 2.0%

(2) f<sub>T</sub> = | hfe | e ftest
(3) ''On'' time is 25 µs. It, decreases with shorter pulse widths, being approximately 50% of the values shown at a 5.0 µs pulse width. \*Indicates JEDEC Registered Data.





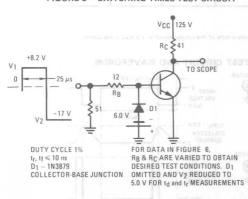
#### FIGURE 4 - ACTIVE-REGION SAFE OPERATING AREA

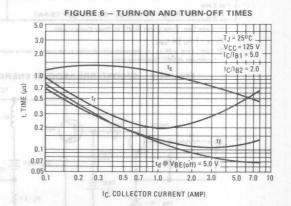


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on  $T_{J(pk)}=200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \stackrel{<}{\approx} 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

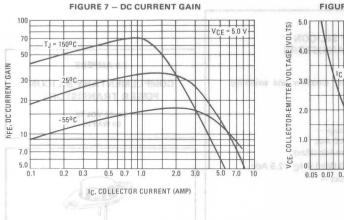
FIGURE 5 - SWITCHING TIMES TEST CIRCUIT

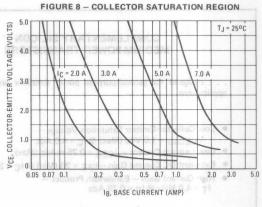


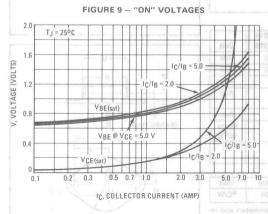


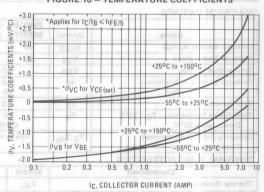
MOTOROLA

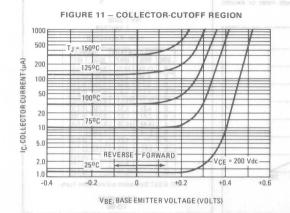


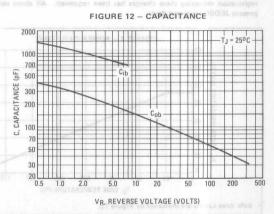














## COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

 $\ldots$  , designed for general-purpose power amplifier and switching applications,

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ I<sub>C</sub> = 4.0 Adc
- Low Leakage Current ICEX = 0.25 mAdc (Max)
- Excellent DC Current Gain hFE = 20 (Min) @ IC = 2.5 Adc
- High Current Gain Bandwidth Product fT = 4.0 MHz @ IC = 0.25 Adc

#### 7.0 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS 90 WATTS



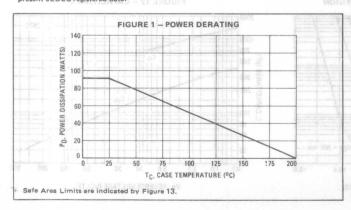
#### \*MAXIMUM RATINGS

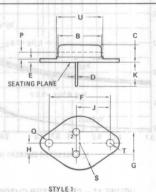
INIAXIINIOINI NATIINGS				1 9 1 1
Rating	Symbol	2N6315 2N6317	2N6316 2N6318	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current — Continuous Peak	and not ave	7.0		Adc
Base Current	1 <sub>B</sub>	2	.0	Adc
Total Device Dissipation — T <sub>C</sub> = 25°C Derate above 25°C	PD	140-02-35	00 515	Watts W/OC
Operating and Storage Junction Temperature Range	TJ, Tstg	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case 11103 at	θJC	1.94	°C/W

<sup>\*</sup>Indicates JEDEC registered data. Limits and conditions differ on some parameters and reregistration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.





STYLE 1: PIN 1. BASE 2. EMITTER CASE: COLLECTOR

	MILLI	METERS	INCHES		
MIC	MIN	MAX	MIN	MAX	
B	11.94	12.70	0.470	0.500	
C	6.35	8.64	0.250	0.340	
D	0.71	0.86	0.028	0.034	
E	1.27	1.91	0.050	0.075	
F	24.33	24.43	0.958	0.962	
G	4.83	5.33	0.190	0.210	
H	2.41	2.67	0.095	0.105	
1	14.48	14.99	0.570	0.590	
K	9.14	-	0.360	-	
P	-	1.27	-	0.050	
0	3.61	3.86	0.142	0.152	
S	11431	8.89	10-1	0.350	
T	-	3.68	-1192	0.145	
U		15.75		0.620	

All JEDEC Dimensions and and Notes Apply.

CASE 80-02 TO-66

3

MEM 2899375 and 2899376

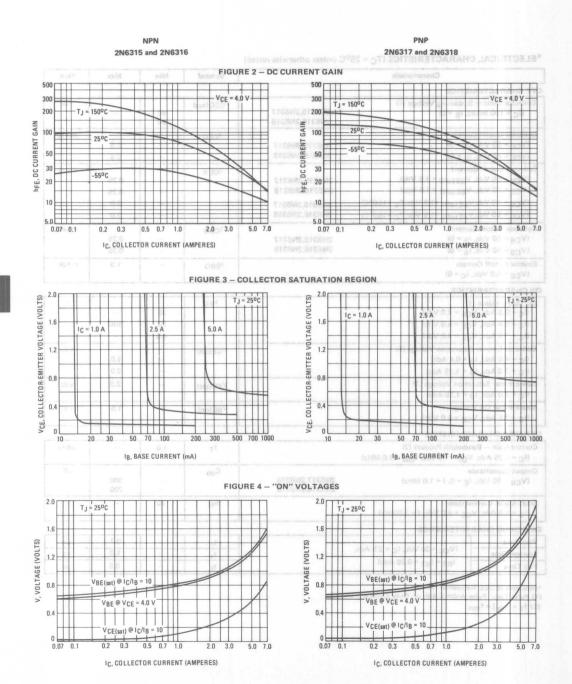
### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	11 000				- 1111
Collector-Emitter Sustaining Voltage (1) (1 <sub>C</sub> = 100 mAdc, 1 <sub>B</sub> = 0)	2N6315,2N6317 2N6316,2N6318	VCEO(sus)	60 80	= 20031	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, 1 <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, 1 <sub>B</sub> = 0)	2N6315,2N6317 2N6316,2N6318	ICEO	<del>-</del>	0.5 0.5	mAdc
Collector Cutoff Current (VCE = 60 Vdc, VBE(off) = 1.5 Vdc) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc) (VCE = 60 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C)	2N6315,2N6317 2N6316,2N6318 2N6315,2N6317 2N6316,2N6318	ICEX	-  -  -  -  -	0.25 0.25 2.0 2.0	mAdc
Collector Cutoff Current	2N6315,2N6317 2N6316,2N6318	1 CBO	OS OF LE	0.25 0.25	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	LECTOR SATERATION	IEBO	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I C = 0.5 Adc, VCE = 4.0 Vdc) (I C = 2.5 Adc, VCE = 4.0 Vdc) (I C = 2.5 Adc, VCE = 4.0 Vdc) (I C = 7.0 Adc, VCE = 4.0 Vdc)	9.1 38.5	hFE A&&	35 20 4.0	100 A 8.7	- I
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 0.4 Adc) (I <sub>C</sub> = 7.0 Adc, I <sub>B</sub> = 1.75 Adc)	1	VCE(sat)		1.0	Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 7.0 Adc, I <sub>B</sub> = 1.75 Adc)	0.00	VBE (sat)		2.5	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 4.0 Vdc)	7-10 8 111	V <sub>BE</sub> (on)		1.5	Vdc
YNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) (I <sub>C</sub> = 0.25 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)		f <sub>T</sub>	4.0 7//3//4//3 3//	- 48 .g)	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	2N6317,2N6318 2N6315,2N6316	C <sub>ob</sub>	_	300 200	pF
Small-Signal Current Gain (IC = 0.5 Adc, VCE = 4.0 Vdc, f = 1.0 kHz)	T 0.5	h <sub>fe</sub>	20	J jees	o I
WITCHING CHARACTERISTICS	1-13.1		THE		
Rise Time  (V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 2.5 Adc,	HI B R	t <sub>r</sub>		0.7	μs
I <sub>B1</sub> = I <sub>B2</sub> = 0.25 Adc)		15		1.0	μ5

Rise Time	() 2011 1 25 1	tr	0.7	μs
Storage Time	(V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 2.5 Adc,	ts	1.0	μs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 0.25 Adc)	tf	0.8	μs

\*Indicates JEDEC Registered Data.

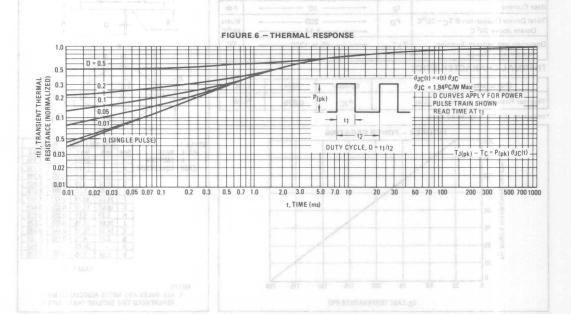
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f<sub>T</sub> = |h<sub>fe</sub>| e f<sub>test</sub>



MOTORCLA

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C}$  –  $V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}=200^{o}C;\,T_{C}$  is variable depending on conditions. Second breakdown pulse limits ariable development of the provided  $T_{J(pk)}<200^{o}C.$   $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



NPN 2N6316, 2N6316

#### HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

High Collector-Emitter Sustaining Voltage —

VCEO(sus) = 100 Vdc (Min) — 2N6338 = 120 Vdc (Min) — 2N6339 = 140 Vdc (Min) — 2N6340

= 150 Vdc (Min) - 2N6341

High DC Current Gain —

hFE = 30-120 @ IC = 10 Adc

= 12 (Min) @ Ic = 25 Adc

 Low Collector-Emitter Saturation Voltage — The Management of the Collection of the Collec VCE(sat) = 1.0 Vdc (Max) @ IC = 10 Adc

• Fast Switching Times @ Ic = 10 Adc

 $t_r = 0.3 \,\mu s \,(Max)$ 

 $t_S = 1.0 \,\mu s \,(Max)$ 

 $t_f = 0.25 \,\mu s \,(Max)$ 

Complement to 2N6436-38

## \*MAXIMUM RATINGS

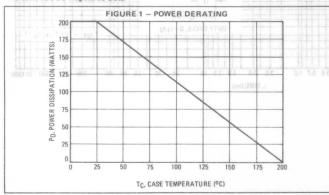
Rating	Symbol	2N6338	2N6339	2N6340	2N6341	Unit
Collector-Base Voltage	VCB	120	140	160	180	Vdc
Collector-Emitter Voltage	VCEO	100	120	140	150	Vdc
Emitter-Base Voltage	VEB	and taking	6.	0	Britis	Vdc
Collector Current — Continuous Peak	lc	25				Adc
Base Current	I <sub>B</sub>	-	1	0		Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	- 21	2	00	HY A R	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to	+200—		°C

S, COLLECTOR-EMITTER VOLTAGE (VOLTS)

#### THERMAL CHARACTERISTICS

Characteristic Manager 1 200	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	0.875	°C/W

\*Indicates JEDEC Registered Data.



25 AMPERE **POWER TRANSISTORS** NPN SILICON

100, 120, 140, 150 VOLTS **200 WATTS** 



		0-		S			
TYLE 1			AJ DI	MILLIMETERS		INCHES	
PIN		BASE	DIM	MIN	MAX	MIN	MAX
-	2.	EMITTER	A	-	39.37	-	1,550
CASE COLLECTOR	В	-	21.08	1220	0.830		
			C	6.35	7.62	0.250	0.300
			D	0.97	1.09	0.038	0.043
			E	1.40	1.78	0.055	0.070
			F	29.90	30.40	1.177	1.197
			G	10.67	11.18	0.420	0.440
			Н	5.33	5.59	0.210	0.220
			J	16.64	17.15	0.655	0.675
			K	11.18	12.19	0.440	0.480
			Q	3.81	4.19	0.150	0.165
			R	-	26.67	-	1.050
			U	2.54	3.05	0.100	0.120

CASE 1-04

ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

\*ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	nauko an	TO COMPANY AS	in central in		
Collector-Emitter Sustaining Voltage (1)		V <sub>CEO(sus)</sub>			Vdc
(IC = 50 mAdc, IB = 0)	2N6338	COUNTY OF THE PARTY OF	100		
	2N6339		120		
	2N6340		140		
	2N6341		150		Service of the last
Collector Cutoff Current		CEO			μAdc
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	2N6338			50	
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	2N6339	1-1		50	
(V <sub>CE</sub> = 70 Vdc, I <sub>B</sub> = 0)	2N6340	1-1-1-1		50	10/
(V <sub>CE</sub> = 75 Vdc, I <sub>B</sub> = 0)	2N6341			50	
Collector Cutoff Current		ICEX		PRINCIPLE	
(VCE = Rated VCEO, VEB(off) = 1.5 Vdc)				10	μAdc
(VCE = Rated VCEO, VEB(off) = 1.5 Vdc, TC =	150°C)			1.0	mAdc
	Jacob M. Control				
Collector Cutoff Current		СВО		10	μAdc
(V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)					
Emitter Cutoff Current		1 <sub>EBO</sub>		100	μAdc
(VBE = 6.0 Vdc, IC = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain	10 28 3	Ld DE 85 9	0.8 0.3 0.5	1.0 20.0	0.02 0.03
		hFE	50		- 1
(I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		(am) 31kiT-,1			1 96
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 2.0 Vdc)			30	120	
(I <sub>C</sub> = 25 Adc, V <sub>CE</sub> = 2.0 Vdc)			12		
Collector-Emitter Saturation Voltage		VCE(sat)			Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc)	OPERATING AREA	HE RECTON SAFE	FIGURES - ACT	1.0	1 1 1 1 1 3
(I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2.5 Adc,			-	1.8	
Base-Emitter Saturation Voltage		VBE(sat)			Vdc
(IC = 10 Adc, IB = 1.0 Adc)				1.8	
(IC = 25 Adc, IB = 2.5 Adc)				2.5	
Base-Emitter On Voltage		VBE(on)		1.8	Vdc
(IC = 10 Adc, VCE = 2.0 Vdc)	are are two limitat	· BE(OII)			
DYNAMIC CHARACTERISTICS	itomi i eguseve i i i i i i i i i i i i i i i i i i	DANT DE			
Current-Gain-Bandwidth Product (2)	DATE TO SERVICE	f <sub>T</sub>	40		MHz
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)	of bayrasido ad tsun	1 Jenij			
Output Canacitance	at perpetation at the	Cob		300	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)		- OB		300	
the tip to the result of the section	ding on conditions.	henen i legen	1/11 186/11	2000	
	an 2001 of splays ye			DATE CALLED	
Rise Time $(V_{CC} \approx 80 \text{ Vdc}, I_C = 10 \text{ Adc}, I_{B1} = 1.0 \text{ Adc}, V_{B1}$	E(off) = 6.0 Vdc)	lupigo tr	10 ss -01	e day 0.3 y LAM	BRIST BEEF BEI
Storage Time	term closic than the	routev ts	25 M - 25 M - 03 M	1.0	μs
(V <sub>CC</sub> ≈ 80 Vdc, I <sub>C</sub> = 10 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 1.0 Ad		contex 's	THE SEE AND THE	ES APELY BELEW-	raup I I cura
OO DI .DZ			granden RESSET L	and the second second	Andrew Manager
Fall Time		t <sub>f</sub>	of the same of the	0.25	μs

\*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width  $\le$  300  $\mu$ s, Duty Cycle  $\le$  2.0%. (2) f<sub>T</sub> =  $\ln_{fe} l_e f_{test}$ .

FIGURE 2 - SWITCHING TIME TEST CIRCUIT

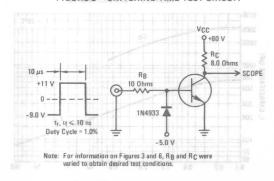
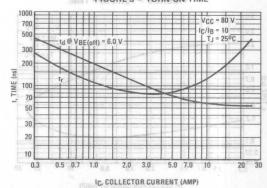


FIGURE 3 - TURN-ON TIME





5.0

2.0

1.0

0.5

0.2

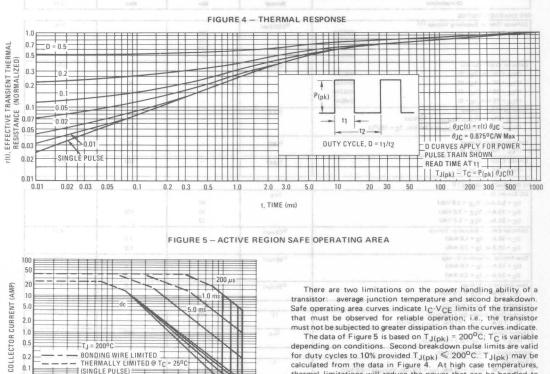
0.1

0.02

0.01

2.0

0.05 ف



transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 200^{\circ} C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

5.0 7.0 10 20 30 50 70 100 VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

(SINGLE PULSE) SECOND BREAKDOWN LIMITED=2N6338

±2N6339 =

2N6340

2N6341

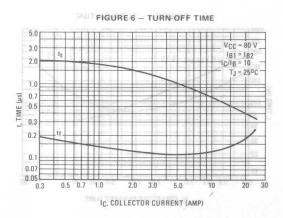
TJ = 200°C

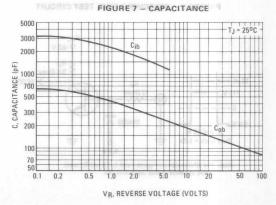
BONDING WIRE LIMITED

CURVES APPLY BELOW

RATED VCEO

- — THERMALLY LIMITED @ TC = 25°C







HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

 High Collector Emitter Sustaining Voltage — VCEO (sus) = 80 Vdc (Min) - 2N6377

= 100 Vdc (Min) - 2N6378 = 120 Vdc (Min) - 2N6379

• High DC Current Gain -

hFE = 30-120 @ IC = 20 Adc = 10 (Min) @ IC = 50 Adc

 Low Collector-Emitter Saturation Voltage — VCE(sat) = 1.0 Vdc (Max) @ IC = 20 Adc

• Fast Switching Times @ Ic = 20 Adc

 $t_r = 0.35 \,\mu s \,(Max)$  $t_S = 0.8 \,\mu s \,(Max)$ 

 $t_f = 0.25 \,\mu s \,(Max)$ 

• Complement to 2N6274-77

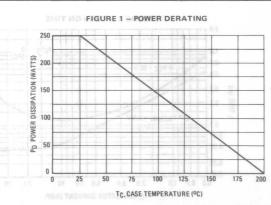
#### \* BAAVIBALIBA DATIBLO

Rating	Symbol	2N6377	2N6378	2N6379	Unit
Collector-Base Voltage	VCB	100	120	140	Vdc
Collector-Emitter Voltage	VCEO	80	100	120	Vdc
Emitter-Base Voltage	VEB	4	6.0	-	Vdc
Collector Current — Continuous Peak	1c		50 100	===	Adc
Base Current	IB	-	20	-	Adc
Total Device Dissipation @  T <sub>C</sub> = 25°C  Derate above 25°C	PD		250 1.43	-	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +200 -	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC 786	0.7	°C/W

\*Indicates JEDEC Registered Data.

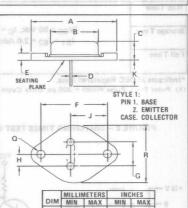


#### 50 AMPERE POWER TRANSISTORS PNP SILICON

80, 100, 120 VOLTS 250 WATTS A 30 - 30VI

(tg = 20 Ade, Vgg = 4.8 Vital



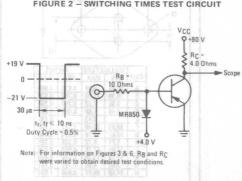


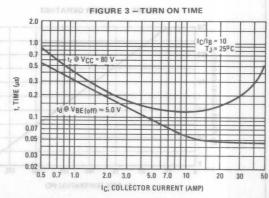
	MILLIMETERS		2 INCHES	
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage <sup>(1)</sup> (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	2N6377 2N6378 2N6379	VCEO(sus)	80 100 120	= - - 	Vdc
Collector Cutoff Current	68(2)	ICEO	2131G 1917	navion-noin	μAdc
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 70 Vdc, I <sub>B</sub> = 0)	2N6377 2N6378 2N6379	Voltage -	_anoites	50 50 50	10 15
Collector Cutoff Current (VCE = 90% Rated VCB, VBE(off) = 1.5 Vdc) (VCE = 90% Rated VCB, VBE(off) = 1.5 Vdc, TC	; = 150°C)	CEX CAND	Vdc (Alin) — Vdc (Hin) — Vdc (Hin) —		μAdc mAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, IC = 0)		<sup>1</sup> EBO	20 Ade	000000000000000000000000000000000000000	μAdc
*ON CHARACTERISTICS (1)			SBA UC =	Or or tunien or =	
DC Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 50 Adc, V <sub>CE</sub> = 4.0 Vdc)		hFE abA 0	50 30 10		VO VO P Fact tr =
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 50 Adc, I <sub>B</sub> = 10 Adc)		VCE(sat)		(xs/1,2 4 35.0 0.25 24.63 0.0000000000000000000000000000000000	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 50 Adc, I <sub>B</sub> = 10 Adc)		VBE(sat)	-	1.8 3.5	Vdc MUMIXAM
DYNAMIC CHARACTERISTICS	300 102895	0460002 11	court Tourns	900	
*Current-Gain — Bandwidth Product (2) (IC = 1.0 Adc, VCE = 10 Vdc, f <sub>test</sub> = 10 MHz)	120 Vac	ofT	30	er Voltage	MHz
*Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	DA -m-	C <sub>ob</sub>	- as	1500 ***********************************	pF
* SWITCHING CHARACTERISTICS (Figure 2)		00			
Rise Time	alla Viatta	t <sub>r</sub>	09	0.35	ο est μs
Storage Time (V <sub>CC</sub> = 80 Vdc, I <sub>C</sub> = 20 I <sub>B1</sub> = I <sub>B2</sub> = 2.0 Adc)	Adc, W	- Chits	- W-   mo 1.7	0.80 0 08.0	ora spisaci
Fall Time	l	tf	108	0.25	Mesames I
*Indicates JEDEC Registered Data.  1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 100 µs,		=  h <sub>fe</sub>   • f <sub>test</sub>	FIGURE 3	RACTERIST Ric Lunction to Car equipmed Data	AR:







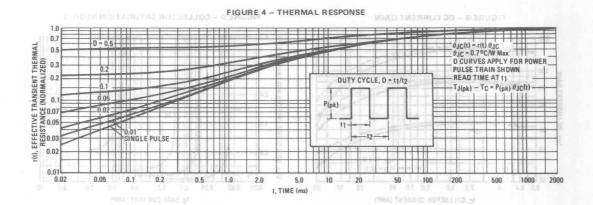
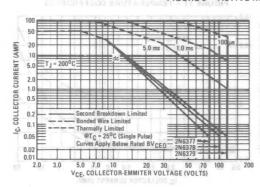
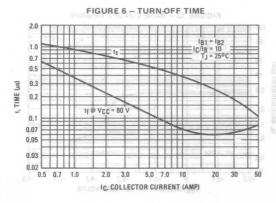


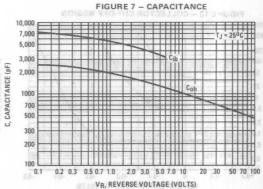
FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA

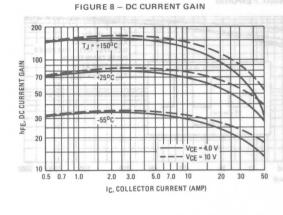


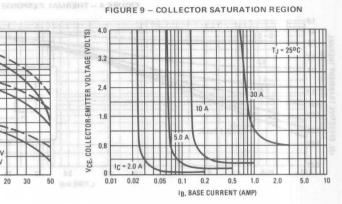
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

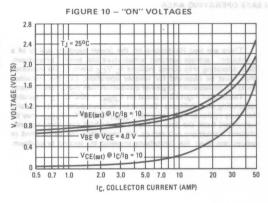
The data of Figure 5 is based on  $T_{J(pk)}=200^{\circ}C$ :  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

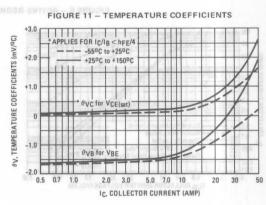


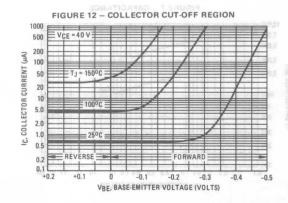


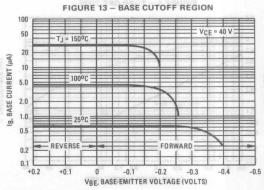














## COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

... monolithic complementary silicon Darlington transistors designed for low and medium frequency power applications such as power switching, audio amplifiers, hammer drivers, and shunt and series regulators.

- High Gain Darlington Performance
- True Complementary Specifications

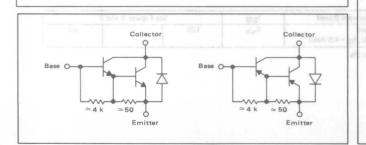
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6383 2N6648	2N6384 2N6649	2N6385 2N6650	Unit
Collector-Emitter Voltage	VCEO(sus)	40	60	80	Vdc
Collector-Emitter Voltage	VCEX	40	60	80	Vdc
Collector-Emitter Voltage	Vсво	40	60	80	Vdc
Emitter Base Voltage	VEBO	4	<del>-</del> 5.0 -	-	Vdc
Collector Current - Continuous : Peak (1) * *	I <sub>C</sub>		— 10 — — 15 —		Adc
Base Current - Continuous	IB	4	<b>—</b> 0.25 <b>—</b>		Adc
Total Power Dissipation  © T <sub>C</sub> = 25°C (2)  Derate above 25°C	PD	4	— 100 — — 0.571 -		Watt
Operating and Storage Junction Temperature Range (2)	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +20	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rojc	1.75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/32" from Case for 5 Seconds	TL	235	°C

- \*Indicates JEDEC Registered Data.
- \*\*Not JEDEC Registered.
- (1) Pulse Width = 50 ms, Duty Cycle ≤ 10%.
- (2) Exceeds JEDEC Registration for 2N6648, 2N6649, 2N6650. JEDEC Registration gives  $P_D = 70 \text{ W}$ ,  $T_J = 150^{\circ}\text{C}$ .

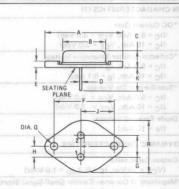


#### 15 AMPERE PEAK

## COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

40-60-80 VOLTS 100 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	-	1.550
В	1 200	21.08	51-12 July	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	18-2 -	3.43	123	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	-	26.67	-	1.050
		CASE 11	01	1.

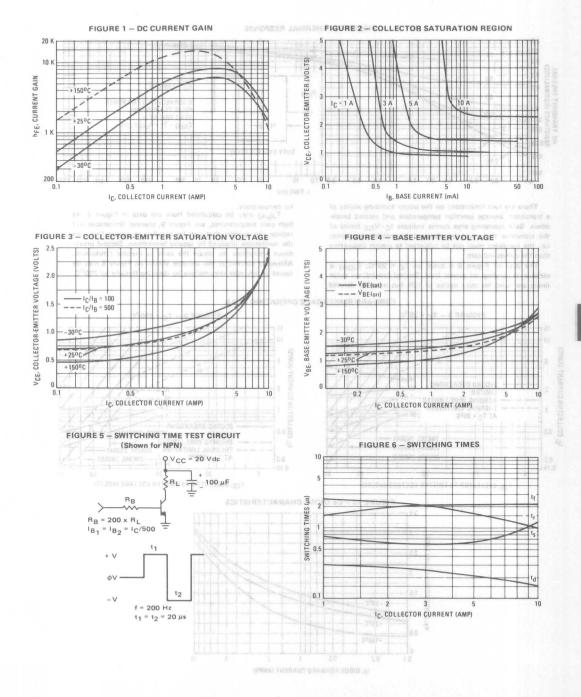


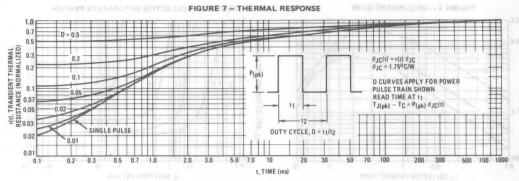




Characteristic		Symbol	OL Min AA	Max Max	Unit
FF CHARACTERISTICS 13.19MOO		DARLINGTON TRANSISTORS			
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N6383, 2N6648 2N6384, 2N6649	VCEO(sus)		ta/nem <u>e</u> lgmas seuden)-muibar	Vdc
8T_IQV 08-08-09	2N6385, 2N6650	and short	80	io ematifiera.	tire an datiwal
Collector Cutoff Current (V <sub>CE</sub> = Rated Value)		ICEO	_	1.0	mAdc
*Collector Cutoff Current (VCE = Rated VCEO(sus) Value, VBE(off) = 1.5 (VCE = Rated VCEO(sus) Value, VBE(off) = 1.5		ICEV	ifications	0.3 3.0	mAdc
*Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO	-	10	mAdc
Collector-Emitter Sustaining Voltage (1) (RBE = 100 \Omega, IC = 200 mA)	2N6383, 2N6648 2N6384, 2N6649 2N6385, 2N6650	VCER(sus)	40 60 80	- so	Vdc
Collector-Emitter Sustaining Voltage (1) (VBE(off) = 1.5 V, I <sub>C</sub> = 200 mA)	2N6383, 2N6648 2N6384, 2N6649 2N6385, 2N6650	VCEV(sus)	40 60 80	- NC	Vdc
IN CHARACTERISTICS (1)	2N0303, 2N0030	08 01	OBOV	9	estor-Emiliar Volta
*DC Current Gain	aby le	hFE	OBAY		meanin V mod m
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	SDA -	ar oli FE	1000	20,000	100 - 111 - Co 101 - 111 - Co
*Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.01 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 0.1 Adc)	200A =	VCE(sat)	- a <sup>9</sup>	2.0 3.0	Vdc
*Base-Emitter On Voltage (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	20	VBE(on)	TaT LT	2.8 4.5	Vdc
Diode Forward Voltage (IF = 10 Adc)		VF	-	20114.0	AAA Vdc
DYNAMIC CHARACTERISTICS	SinU I	sM loday	8	alteristic	
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 MHz)	3°	Cob	- E1	200	pqmg pF
*Magnitude of Common-Emitter Small-Signal Short-Current Transfer Ratio (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 MHz)	Circuit	Ihfel	20	gistered Data. ed.	Net JEDS Register
Common Emitter Small-Signal Short-Circuit Forwar  Current Transfer Ratio  (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 kHz)	d.	h <sub>fe</sub>	1000		n Do — <u>o</u> naw sai is Broseds — DBC (1915) BDEC Projetration
ECOND BREAKDOWN					
Second Breakdown Collector Current with Base-Forward Biased		I <sub>S/B</sub>	S	See Figures 8 and 9	
Second Breakdown Energy with Base Reverse-Biased (L = 12 mH, RBE = 100 $\Omega$ , VBE(off) = 1.5 Vdc,		E <sub>s/b</sub>	120	toropho S	mJ
1) Pulse Test: Pulse Width = $300  \mu s$ , Duty Cycle $\leqslant$ 1 Indicates JEDEC Registered Data.	2%.	7	O HISTO	1	Sass :







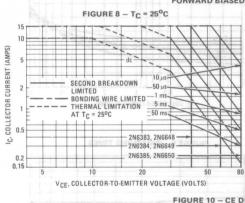
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

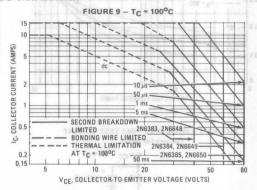
The data of Figure 8 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated

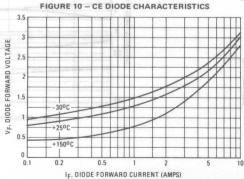
for temperature

T<sub>J</sub>(p<sub>k</sub>) may be calculated from the data in Figure 7. At high case temperatures, see Figure 9, thermal limitations will reduce the current that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do derate the same as thermal limitations. Allowable current at the voltages shown on Figure 8 may be found at any case temperature by derating linearly to 200°C.

#### FORWARD BIASED SAFE OPERATING AREA







3

#### PLASTIC MEDIUM-POWER SILICON TRANSISTORS

... designed for general-purpose amplifier and low-speed switching applications.

High DC Current Gain —

hFE = 2500 (Typ) @ IC = 4.0 Adc

Collector-Emitter Sustaining Voltage — @ 100 mAdc

VCEO(sus) = 40 Vdc (Min) - 2N6386

- = 60 Vdc (Min) 2N6387
- = 80 Vdc (Min) 2N6388

 Low Collector-Emitter Saturation Voltage — VCE(sat) = 2.0 Vdc (Max) @ IC = 3.0 Adc - 2N6386

= 2.0 Vdc (Max) @ IC = 5.0 Adc - 2N6387, 2N6388

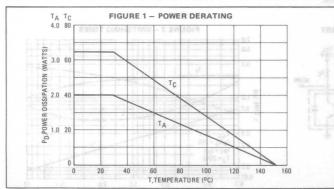
- Monolithic Construction with Built-In Base-Emitter **Shunt Resistors**
- TO-220AB Compact Package
- TO-66 Leadform Also Available

#### \*MAXIMUM RATINGS

Rating	Symbol	2N6386	2N6387	2N6388	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	V <sub>CB</sub>	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	— 5.0 —	BEET BUILD	Vdc
Collector Current — Continuous Peak	Ic	8.0 15	10 15	10 15	Adc
Base Current	IB	-	250	DELCOPES.	mAdd
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4	65 0.52	ngggute	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	-	2.0 0.016	==	Watts W/OC
Operating and Storage Junction, Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +15	0	°c

#### THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.92	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

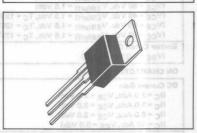


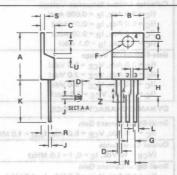
#### DARLINGTON 8 AND 10 AMPERE

ELECTRICAL CHARACTERISTICS (To - 28°C unless orberwise noted)

#### NPN SILICON **POWER TRANSISTORS**

40-60-80 VOLTS 65 WATTS





	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

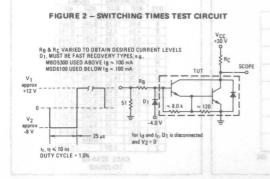


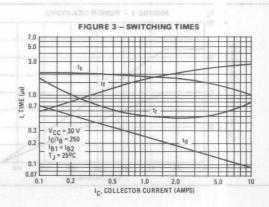
#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N6386 2N6387 2N6388	VCEO(sus)	40 60 80	PLAST SILICE of generals	Vdc
Collector Cutoff Current (VCE = 40 Vdc, I <sub>B</sub> = 0) (VCE = 60 Vdc, I <sub>B</sub> = 0) (VCE = 80 Vdc, I <sub>B</sub> = 0)	2N6386 2N6387 2N6388	ICEO	oloA (Ca) × ol Luncula / Turning	1.0 1.0 1.0	mAdc
Collector Cutoff Current  (VCE = 40 Vdc, VEB(off) = 1.5 Vdc)  (VCE = 60 Vdc, VEB(off) = 1.5 Vdc)  (VCE = 80 Vdc, VEB(off) = 1.5 Vdc)  (VCE = 40 Vdc, VEB(off) = 1.5 Vdc, TC = 125°(  (VCE = 40 Vdc, VEB(off) = 1.5 Vdc, TC = 125°(  (VCE = 80 Vdc, VEB(off) = 1.5 Vdc, TC = 125°(	C) 2N6387	CEX 86:00 78:00 63:08 - 2.0 Ade - 2NG 63:00 Ade - 2NG	c (Min) – 29 c (Min] – 29 c (Min) – 21 sturetton Vc t (Max+ © 1c t (Max+ © 1c	300 300 300 3.0 3.0 3.0	μAdc mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	with Built-F	5.0	mAdc
ON CHARACTERISTICS (1)				0	LOOK ACT IN
DC Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N6386 2N6387, 2N6388 2N6386	hFE	1000 1000 100	20000 20000 —	
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N6387, 2N6388	TRIVAGE, LANGIN	100	20	Tall Vide
Collector-Emitter Saturation Voltage (IC = 3.0 Adc, I <sub>B</sub> = 0.006 Adc) (IC = 5.0 Adc, I <sub>B</sub> = 0.01 Adc) (IC = 8.0 Adc, I <sub>B</sub> = 0.08 Adc) (IC = 10 Adc, I <sub>B</sub> = 0.1 Adc)	2N6386 2N6387, 2N6388 2N6386 2N6387, 2N6388	VCE(sat)	6710 V E3 V = 88 V	2.0 2.0 3.0 3.0	Vdc V mt (n3-iot) stioV >s0-ioti ssioV sw8-ns
Base-Emitter On Voltage (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N6386 2N6387, 2N6388 2N6386 2N6387, 2N6388	VBE(on)	= -gg	2.8 2.8 4.5 4.5	Vdc
DYNAMIC CHARACTERISTICS	273014	2.9	e g9	Ion @ TA = 250C	Power Disloat
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	20 6	Ihfel	20	a Junction.	nere allowed Store
Output Capacitance (VCR = 10 Vdc, IF = 0, f = 1.0 MHz)		C <sub>ob</sub>		200 317213173A1	PF MAND JAME
Small-Signal Current Gain (IC = 1.0 Adc, VCF = 5.0 Vdc, f = 1.0 kHz)	tinti	h <sub>fe</sub>	1000	eoffe afres	HERE HERE

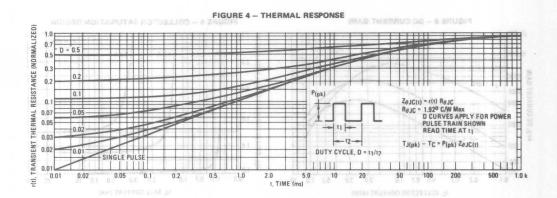
#### Indicates JEDEC Registered Data

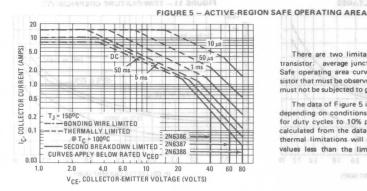
<sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.





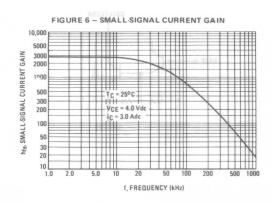


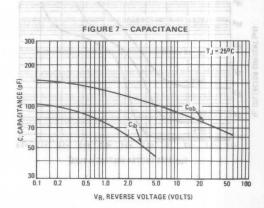


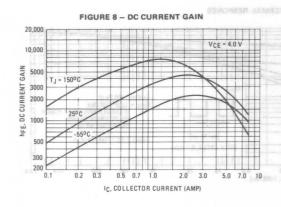


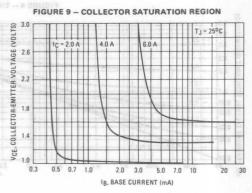
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C}-V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

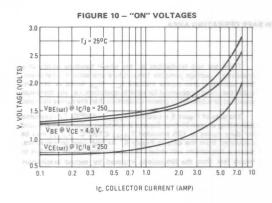
The data of Figure 5 is based on  $T_{J(pk)}=150^{\rm o}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}<150^{\rm o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown











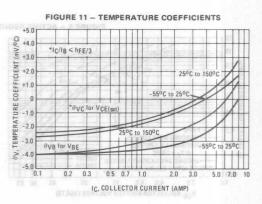
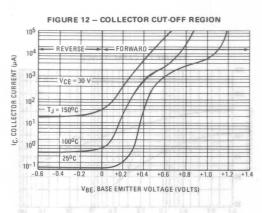
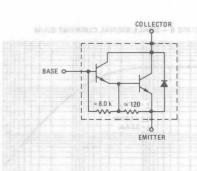


FIGURE 13 - DARLINGTON SCHEMATIC





#### HIGH-POWER PNP SILICON TRANSISTORS

...designed for use in industrial-military power amplifier and switching circuit applications.

- High Collector-Emitter Sustaining Voltage –
   VCEO(sus) = 80 Vdc (Min) 2N6436
   = 100 Vdc (Min) 2N6437
  - = 120 Vdc (Min) 2N6438
- High DC Current Gain —
   hFE = 20-80 @ I<sub>C</sub> = 10 Adc
   = 12 (Min) @ I<sub>C</sub> = 25 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 10 Adc
- Fast Switching Times @ IC = 10 Adc
  - $t_r = 0.3 \,\mu s \,(Max)$   $t_s = 1.0 \,\mu s \,(Max)$  $t_f = 0.25 \,\mu s \,(Max)$
- Complement to NPN 2N6338 thru 2N6341

#### 25 AMPERE POWER TRANSISTORS PNP SILICON

80, 100, 120 VOLTS 200 WATTS



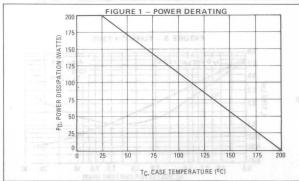
#### \*MAXIMUM RATINGS

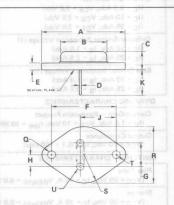
Rating	Symbol	2N6436	2N6437	2N6438	Unit
Collector-Base Voltage	VCB	100	120	140	Vdc
Collector-Emitter Voltage	VCEO	80	100	120	Vdc
Emitter-Base Voltage	VEB	+	— 6.0 —	-	Vdc
Collector Current — Continuous Peak	lc lc	-	25 50		Adc
Base Current	IB	+	10	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		200 —	-	Watte W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.875	°C/W

\*Indicates JEDEC Registered Data.





STYLE 1	BASE EMITTER COLLECTOR	DIM	MILLIMETERS		INCHES	
			MIN	MAX	MIN	MAX
		Α	A 7010	39.37		1,550
		В	_	21.08		0.830
		C	6.35	7.62	0.250	0.300
		D	0.97	1.09	0.038	0.043
		E	1.40	1.78	0.055	0.070
		F	29.90	30.40	1.177	1.197
		G	10.67	11.18	0.420	0.440
		Н	5.33	5.59	0.210	0.220
		J	16.64	17.15	0.655	0.675
		K	11.18	12.19	0.440	0.480
		Q	3.81	4.19	0.150	0.165
		R	-	26.67	_	1.050
		U	2.54	3.05	0.100	0.120

CASE1-04

NOTES:

1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

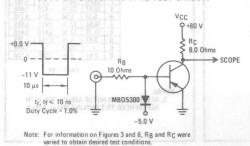
#### \*ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (1 <sub>C</sub> = 50 mAdc, 1 <sub>B</sub> = 0)	2N6436 2N6437 2N6438		VCEO(sus)	80 100 120	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	2N6	6436 6437 6438	SIZVACET IN	NP SILICO industial n	50 ni 50 10	PAdc OH <sup>μ</sup> Adc
Collector Cutoff Current   Collector Cutoff Cutoff   Collector Cutoff   Collector Cutoff Cutoff   Collector Cutoff   Collecto	2N6437 2N6438 2N6436 2N6437		16436 N6437	to (Min) — 2 to (Min) — 2 - 10 Adg	10 (aug)	VCEO MAdc
Collector Cutoff Current $(V_{CB} = 100 \text{ Vdc},  _{E} = 0)$ $(V_{CB} = 120 \text{ Vdc},  _{E} = 0)$ $(V_{CB} = 140 \text{ Vdc}, 1_{E} = 0)$	2N6436 2N6437 2N6438		ICBO SESSION	l PC = 1 <u>0</u> ∀qi   Maxi @ txe(w)   Logarian	10 10 10	VCE
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0)			IEBO	-	(100) 20,0	μAdc
ON CHARACTERISTICS			(APDIN	n all bernett	NC 10010 -0 500	
DC Current Gain (1) (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 25 Adc, V <sub>CE</sub> = 2.0 Vdc)			hFE	30 20 12	- 80 - 80	PYAR MU
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2.5 Adc)	Velc	27 2NG138	VCE(sat)	Symbol 2 Vce_	1.0	Self Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2.5 Adc)	Vdc.	120	VBE(sat)	TaaV	1.8 2.5	Vdc
YNAMIC CHARACTERISTICS			07			
Current-Gain — Bandwidth Product (I <sub>C</sub> = 1.0 Adç, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)	ahA		or fT	40	-	MHz
Output Capacitance (V <sub>CE</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	Do M	*	C <sub>ob</sub>	-01	700	OPES PF
WITCHING CHARACTERISTICS	20		+ 0) \$8	- 121-41	speranut	aperers bill
Rise Time (V <sub>CC</sub> = 80 Vdc, I <sub>C</sub> = 10 A, V <sub>BE(off)</sub> = 6.0 Vd	c, I <sub>B1</sub> =	1.0 Adc)	t <sub>r</sub>		0.3 POLITERISTON	μs L CHARL
Storage (V <sub>CC</sub> = 80 Vdc, I <sub>C</sub> = 10 A, V <sub>BE(off)</sub> = 6.0 Vd	c, I <sub>B1</sub> =	I <sub>B2</sub> = 1.0 Adc)	t <sub>Sladiny</sub> ?	1-	1.0	<sub>σείνως</sub> μς
Fall Time (V <sub>CC</sub> = 80 Vdc, I <sub>C</sub> = 10 A, V <sub>BE(off)</sub> = 6.0 Vdc, I	WY	= 1 0 Ada)	tf DIBH		0.25	μѕ

\*Indicates JEDEC Registered Data.

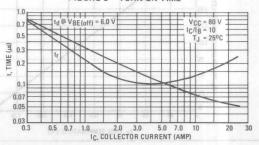
(1) Pulse Test: Pulse Width ≤ 300 µs; Duty Cycle ≤ 2.0%.

#### FIGURE 2 - SWITCHING TIME TEST CIRCUIT



#### FIGURE 3 - TURN-ON TIME

MOTOROLA

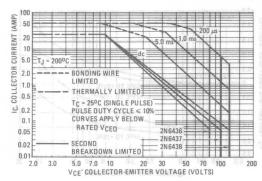




MOIDER MOITARUTAE ROTDELLOS - @ FIGURE 4 - THERMAL RESPONSE P(pk) t1  $Z_{\theta JC(t)} = r(t) R_{\theta JC}$   $R_{\theta JC} = 0.875^{\circ}C/W Max$ DUTY CYCLE, D = t1/t2 D CURVES APPLY FOR POWER PULSE TRAIN SHOWN £, 0.02 READ TIME AT t1  $T_{J(pk)} - T_{C} = P_{(pk)} Z_{\theta JC(t)}$ 0.01 0.1 0.2 0.3 0.5 2.0 3.0 5.0 10 20 30 50 100 200 300 1.0

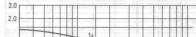
#### THE DESCRIPTION OF THE PROPERTY OF THE PROPERT

t, TIME (ms)



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leqslant 200^{\circ}C$ ,  $T_J(pk)$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



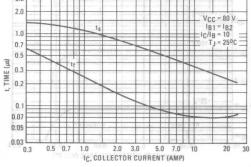
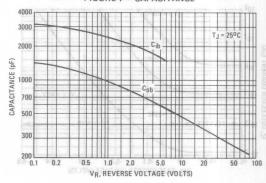
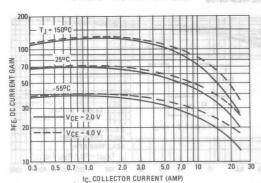


FIGURE 6 - TURN-OFF TIME

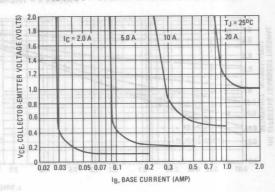


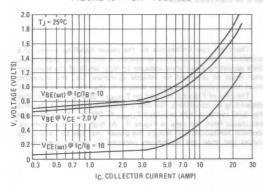






#### FIGURE 8 - DC CURRENT GAIN 384098284 JAMPS TO FIGURE 9 - COLLECTOR SATURATION REGION





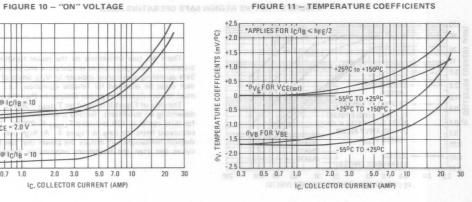


FIGURE 12 - COLLECTOR CUT-OFF REGION

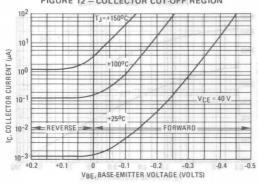
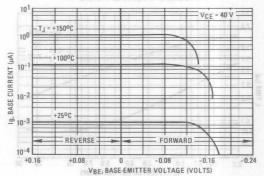


FIGURE 13 - BASE CUT-OFF REGION



"ELECTI CAL CHARACTERISTICS ITC - 25°C unless othe

#### COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 15 Amperes hFF = 20-150 @ IC = 5.0 Adc
  - = 5.0 (Min) @ IC = 15 Adc
- Collector-Emitter Sustaining Voltage
  - VCEO (sus) = 40 Vdc (Min) 2N6486, 2N6489
    - = 60 Vdc (Min) 2N6487, 2N6490 = 80 Vdc (Min) - 2N6488, 2N6491
- High Current Gain Bandwidth Product fT = 5.0 MHz (Min) @ IC = 1.0 Adc
- TO-220AB Compact Package
- TO-66 Leadform Also Available

#### \*MAXIMUM RATINGS 2N6486 2N6489 2N6487 2N6490 2N6488 2N6491 Rating Symbol Unit Collector-Emitter Voltage 40 60 80 Vdc VCEO Vdc Collector-Base Voltage $V_{\mathsf{CB}}$ 50 70 90 Emitter-Base Voltage 5.0 Vdc VEB Collector Current - Continuous 1c 15 Adc Adc Base Current 5.0 IB Total Power Dissipation PD @ T<sub>C</sub> = 25°C Watts Derate above 25°C W/°C 0.6 -Total Power Dissipation PD @ TA = 25°C Watts Derate above 25°C 0.014 W/°C

#### THERMAL CHARACTERISTICS

Operating and Storage Junction

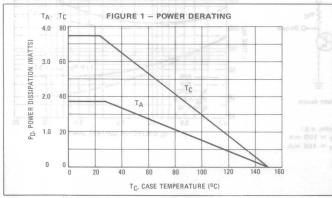
Temperature Range

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.67	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	70	°C/W

TJ, Tstg

65 to +150

\*Indicates JEDEC Registered Data

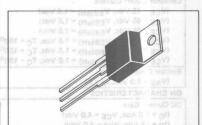


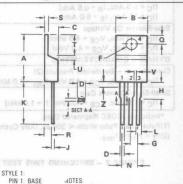
#### 15 AMPERE

(1g = . . . . 0 m Adc, (g = 0)

#### COMPLEMENTARY SILICON POWER TRANSISTORS

40-60-80 VOLTS 75 WATTS





1. DIMENSION H APPLIES TO ALL LEADS. 2. COLLECTOR 3. EMITTER 2. DIMENSION L APPLIES TO LEADS 1

	MILLIN	IETERS	INC	HES
IM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
V	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

°C

## 2N6486 2N6487 2N6488 NPN 2N6489 2N6490 2N6491 PNP

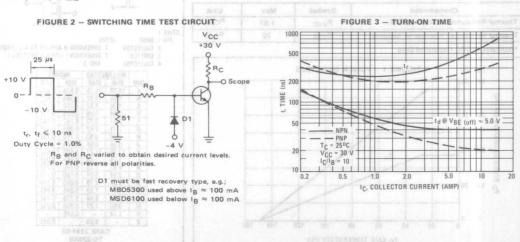


\*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N648	6, 2N6489 7, 2N6490 8, 2N6491	VCEO(sus)	40 60 80	OMPERMEN POWI	Vdc
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, V <sub>BE</sub> = 1.5 Vdc)	2N648 2N648	6, 2N6489 7, 2N6490 8, 2N6491	VCEX	50 70 90	the second second second	application e
Collector Cutoff Current (VCE = 20 Vdc, IB = 0) (VCE = 30 Vdc, IB = 0) (VCE = 40 Vdc, IB = 0)	2N648	6, 2N6489 7, 2N6490 8, 2N6491	ICEO	4	1.0 1.0 1.0	mAdc
Collector Cutoff Current (VCE = 45 Vdc, VEB(off) = 1.5 Vdc) (VCE = 65 Vdc, VEB(off) = 1.5 Vdc) (VCE = 85 Vdc, VER(off) = 1.5 Vdc)	2N648	6, 2N6489 7, 2N6490 8, 2N6491	Tenans, ser	c $(Min) - 2M6$ c $(Min) - 2M6$	500 500	μAdc
(VCE = 40 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 150°( (V <sub>CE</sub> = 60 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°( (V <sub>CE</sub> = 80 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°(	c) 2N648 c) 2N648	6, 2N6489 7, 2N6490	13	ndwieth Prode 9 to =[1.0 Add: skage –	5.0 5.0 5.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			IEBO	<del>9</del> Idaliaw	paiA 1.0 olises	mAdc
ON CHARACTERISTICS					20141	CAR MUNICIPAL
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)	tinQ -	2NG480 2NB421	SEANCE BE	20 5.0	150	State of Contract
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc) (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 5.0 Adc)	atiV seV	00	VCE(sat)	Vcs 80	1.3 3.5	Vdc
Base-Emitter On Voltage	nbA	4	VBE(on)	- a ai	1.3	Vdc
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)				1 0	3.5	Church : BARBLA
	eticW	4	25		3.5	Fewer Onnig
(I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)  DYNAMIC CHARACTERISTICS		-	f <sub>T</sub>	5.0	3.5 home	MHz
(IC = 15 Adc, VCE = 4.0 Vdc)  DYNAMIC CHARACTERISTICS  Current Gain — Bandwidth Product (2)	esew	4	f <sub>T</sub>	5.0	_ 50	MHz

<sup>\*</sup>Indicates JEDEC Registered Data.

(2)fT = |hfe| • ftest.



<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.



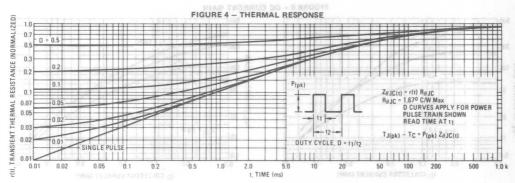
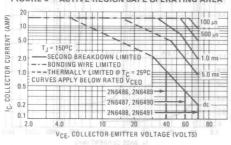


FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on  $T_{J(pk)}=150^{\circ}\mathrm{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}\mathrm{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown

FIGURE 6 - TURN-OFF TIME

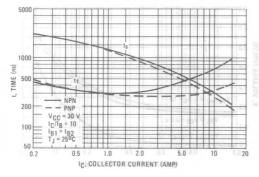
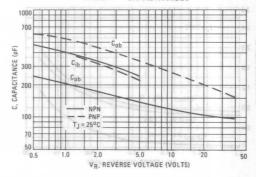


FIGURE 7 - CAPACITANCES

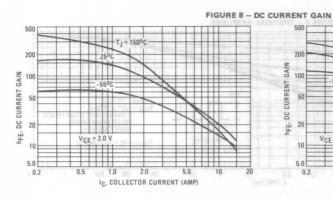


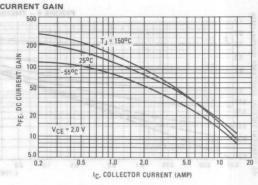
### 2N6486 2N6487 2N6488 NPN 2N6489 2N6490 2N6491 PNP

2N6486 2N6487 2N6488 NPN 2N6489 2N6490 2N6491 PNP

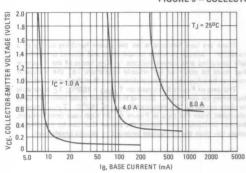
NPN 2N6486, 2N6487, 2N6488

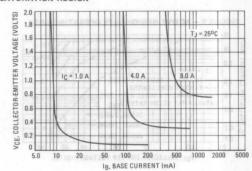
PNP 2N6489, 2N6490, 2N6491



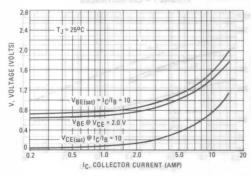


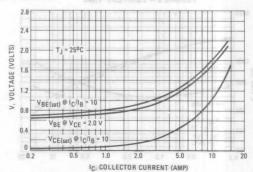
#### FIGURE 9 - COLLECTOR SATURATION REGION





#### FIGURE 10 - "ON" VOLTAGES





3

· · · designed for high voltage inverters, switching regulators and lineoperated amplifier applications. Especially well suited for switching power supply applications.

 High Collector-Emitter Sustaining Voltage — VCEO(sus) = 250 Vdc (Min) - 2N6497

= 300 Vdc (Min) - 2N6498 = 350 Vdc (Min) - 2N6499

 Excellent DC Current Gain hFE = 10 - 75 @ IC = 2.5 Adc

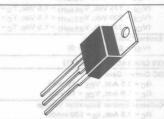
Low Collector-Emitter Saturation Voltage @ IC = 2.5 Adc —

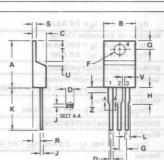
VCE(sat) = 1.0 Vdc (Max) - 2N6497 = 1.25 Vdc (Max) - 2N6498

= 1.5 Vdc (Max) - 2N6499

#### 5 AMPERE **POWER TRANSISTORS** NPN SILICON

250, 300, 350 VOLTS 80 WATTS





STYLE 1:
PIN 1. BASE
2. COLLECTOR 3. EMITTER 4 COLLECTOR

	MILLIM		INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
1	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	80-48	0.045	-
Z	-	2.03	-	0.080

TO-220AB

*MAXIMUM RATINGS					
Rating	Symbol	2N6497	2N6498	2N6499	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	V <sub>CB</sub>	350	400	450	Vdc
Emitter-Base Voltage	VEB	4	6.0 _	-	Vdc
Collector Current — Continuous — Peak	1C	4	5.0 10	<b>→</b>	Adc
Base Current	1 <sub>B</sub>	4	2.0 _	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	*	— 80 - — 0.64 -	<b></b>	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	*	-65 to +150	) <b>—&gt;</b>	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.56	°C/W

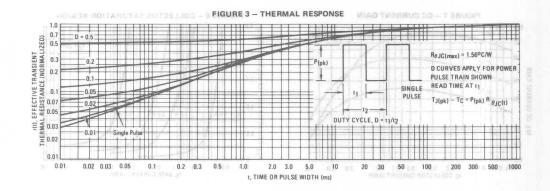
\*Indicates JEDEC Registered Data.



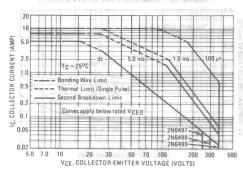
Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)		VCEO(sus)				Vdc
(I <sub>C</sub> = 25 mAdc, I <sub>B</sub> = 0)	2N6497		250		-	L. Bally
	2N6498	MART REN	300	MENTALITY	OLTAGE	A HERM
296, 396, 396 VOLTS	2N6499		350	-	-	177.03
Collector Cutoff Current		ICEX				mAdc
(VCE = 350 Vdc, VBE(off) = 1.5 Vdc)	2N6497	thing regulate	glays—graphs	voi spallov	1.0	gizab a sa
(V <sub>CE</sub> = 400 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)	2N6498	of batius they	Especially		101.0	
(V <sub>CE</sub> = 450 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)	2N6499		-	-anoi	50 1.0 Vice	DE 13WDQ
(VCE = 175 Vdc, VBE(off) = 1.5 Vdc, TC = 100°C)	2N6497	1	-	-	10	11166
(V <sub>CE</sub> = 200 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)	2N6498	- 6	stleV pain	HERRY SUSTAI	10 10	rigiti 6
$(V_{CE} = 225 \text{ Vdc}, V_{BE(off)} = 1.5 \text{ Vdc}, T_{C} = 100^{\circ}\text{C})$	2N6499	T V	2000 - (n	50 Vils (Mi	10	W
Emitter Cutoff Current		IEBO 8	PARTS - (n	Min ataV 00	1.0	mAdc
$(V_{BE} = 6.0 \text{ Vdc}, I_{C} = 0)$		8	N - RNBAS	(M) sbV 68	=	
ON CHARACTERISTICS (1)						
DC Current Gain		hFE		- nide the	neO OC the	BoxEF 6
(I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 10 Vdc)			10		75	
(IC = 5.0 Adc, VCE = 10 Vdc)			3.0	@ IC = 2.5	3	3/1
Collector-Emitter Saturation Voltage		VCE(sat)				Vdc
(I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 500 mAdc)	2N6497 - 55	d C = 01 9 1	garle-V noit	וננסר לאנטרפ	m3 1.0 allo	woJ 0
	2N6498		- 2NB497	Vide (Hax)	1.25	yV III
	2N6499		e alvada	маМ/Гэр V 8	2 1.5	
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 2.0 Adc)	All Devices		- 2N6499	(xsM) obV	5.0	C. Jack
Base-Emitter Saturation Voltage		VBE(sat)				Vdc
(I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 500 mAdc)			-	-	1.5	1 1
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 2.0 Adc)			-	-	2.5	
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product		fT	5.0			MHz
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)						
Output Capacitance		Cob	-	-	150	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)						-
SWITCHING CHARACTERISTICS						
Rise Time		tr	-	0.4	1.0	μs
(V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 2.5 Adc, I <sub>B1</sub> = 0.5 Adc)			March 1		SOUTH	ST AVELLANDS
Storage Time		ts		1.4	2.5	μs
(VCC = 125 Vdc, IC = 2.5 Adc, VBE = 5.0 Vdc, IB1 =	182 = 0.5 Adc)	E043NE 70	misol 2N6.N	43	DH126.7	
Fall Time	350 A A	te	PS - 083	0.45	1.0	197/11/ <b>µs</b> 1979
(VCC = 125 Vdc, IC = 2.5 Adc, IB1 = IB2 = 0.5 Adc)	ANV 000	603	35	/	000-00	ov espilante
*Indicates JEDEC Registered Data.	30.7		32			
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%	obW -g-				-	nov seas volt
234367 26173190,156	DDA ME	0.8				
FIGURE 1 CONTOURS THE TEST CIRCLES			FIGURE	2 - TURN-	ONTIME	
FIGURE 1 – SWITCHING TIME TEST CIRCUIT	suA -est	0.5	FIGURE	Z - TURN-	ON THE	menuQ
VCC 4.06 (4.12 (0.190 (0.190 )		1.0		1 1		111
219 0   220 0   28 0   14 0   0   +125 V	ODW -	0.7		C = 125 V	1111 04	1
25 με 1 360 0 18 2 14 18 1	20	0.5	T	B = 5.0 J = 25°C		/
	≈ 50	0.3	1		1900	/
11 V R <sub>B</sub> ≈ 20	O SCOPE	0.2	W X	tr	11111	
) (K)		E (us)			1111	THE SHARE
-9.0 V	tinkl	₩ 0.1				+ + +
List constate a Di		- 0.07				
2200 2000 ec 1 900 2 T		0.05		1		
t <sub>r</sub> , t <sub>f</sub> ≤ 10 ns		0.03			7	
OUTY CYCLE = 1.0%	LEVELS	0.02		td @ VBE(off	) = 5.0 V	
		0.02				
RB and RC VARIED TO OBTAIN DESIRED CURRENT			++++	-++	11111	1
D1 MUST BE FAST RECOVERY TYPE,  MBD5300 USED ABOVE I8 ~100	, eg:	0.01	7 01 0:	2 03 05	0.7 1.0	

3



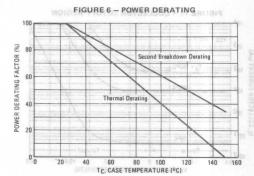


STABISHED BAUTANES FIGURE 4 - ACTIVE-REGION SAFE OPERATING AREA

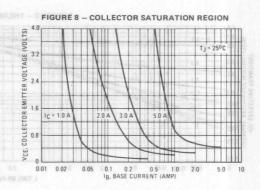


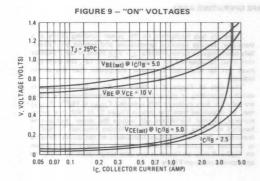
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

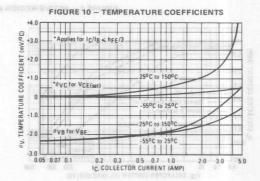
The data of Figure 4 is based on  $T_C=25^{o}C;\;T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to  $10\% \; \mathrm{provided} \; T_{J(pk)} \lesssim 150^{o}C.\;T_{J(pk)}$  may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 4 may be found at any case temperature by using the appropriate curve on Figure 6.

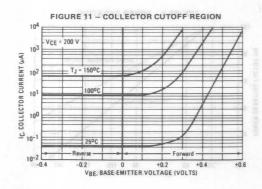


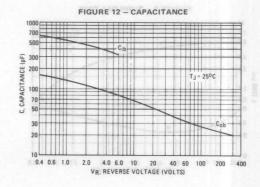
3-251













#### Designers Data Sheet

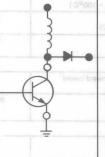
#### SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

These devices are designed for high-voltage, high-speed, power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 volt line operated SWITCHMODE applications such as:

- Switching Regulators
- PWM Inverters and Motor Controls
- Solenoid and Relay Drivers
- Deflection Circuits

Leakage Currents

Specification Features -High Temperature Performance Specified for: Reversed Biased SOA with Inductive Loads O Switching Times with Inductive Loads Saturation Voltages



*MAXIMUM RATINGS				
Rating	Symbol	2N6542	2N6543	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	350	450	Vdc
Collector-Emitter Voltage	VCEV	650	850	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current - Continuous - Peak (1)	ICM		0	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>		.0	Adc
Emitter Current — Continuous — Peak (1)	IEM	1597	0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	57	00 7.2 57	Watts W/OC
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

\*Indicates JEDEC Registered Data

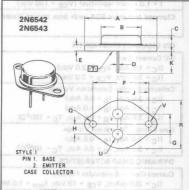
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 5 AMPERE NPN SILICON **POWER TRANSISTORS**

300 and 400 VOLTS 100 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design.



- NOTES:
  1. DIMENSIONS Q AND V ARE DATUMS.
  2. T. IS SEATING PLANE AND DATUM.
  3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:

  - # 0.13 (0.005) M T V M FOR LEADS:
- ♦ 0.13 (0.005) M T VM QM 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973

	MILLI	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	0.70	39.37	1-	1.550	
В	200	21.08	-	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30,15	BSC	1.187 BSC		
G	10.92	BSC	0.430 BSC		
H	5.48	BSC	0.215 BSC		
J	16.89	BSC	0.665 BSC		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R		26.67		1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

**CASE 1-05** TO-204AA

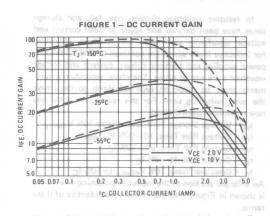
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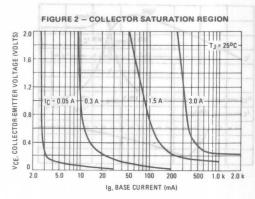
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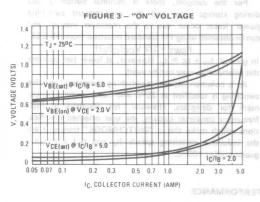


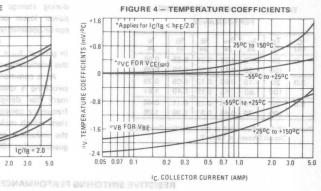
	HE SE MITTER	Symbol	Min	Max	Unit
OFF CHARACTERISTICS (1)		D. P. S. W. M.		ALKE BELLEVILLE	
Collector-Emitter Sustaining Voltage (Table 2)		VCEO (sus)			Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)	MJ4400 MJ4401		300	-	
8T JOV 000 5rc 005		2000	400	0.000.0000	Vdc
Collector-Emitter Sustaining Voltage (Table 2, Figure		VCEX(sus)	350	SWILC	Vdc
(I <sub>C</sub> = 2.6 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C		RANSISTORS	450	NPN SILICON	
(IC = 5.0 Adc, V <sub>clamp</sub> = Rated V <sub>CEO</sub> -100 V,	MJ4401 MJ4400	es, high-speed, pay	200	F banal <del>e</del> do ons astri	
Tc = 100°C)	MJ4401	ritical. They are p	300	enados atisasia esta	
Collector Cutoff Current	-spilige 3	ICEV	nago nrift Ji	116 and 220 vi	mAdc
(VCEV = Rated Value, VBE (off) = 1.5 Vde)			-	0.5	
(VCEV = Rated Value, VBE(off) = 1.5 Vdc, TC =	100°C)		-	3.0	
Collector Cutoff Current		ICER	-	20 3.0 00 B gr	mAdc
(V <sub>CE</sub> = Rated V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	2		algrano 3 n		13/29/9 0
Emitter Cutoff Current	}	IEBO	- 275	vind value bas tie	mAdc
(VEB = 8.0 Vdc, IC = 0) or naving and	a bet a				
SECOND BREAKDOWN	8				
Second Breakdown Collector Current with base forw	ard biased	IS/by hain	0.2	Jya Q a Titte 10 avf	Adc
t = 1.0 s (non-repetitive) (V <sub>CE</sub> = 100 Vdc)		A CONTRACTOR OF THE PARTY OF TH	(See F	igure 11)	A Military
Clamped Inductive SOA with base reverse biased	Carl Carl	RBSOA		igure 12)	C1040 .
200503		all		and Times with line	
	- Y			vegazio vi notz	E RESSO
ON CHARACTERISTICS (1)				1	1
DC Current Gain		pEE	40		-
(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 2.0 Vdc)			12 7.0	60	
Collector-Emitter Saturation Voltage		VCE (sat)	7.0	- 00	Vdc
(IC = 3.0 Adc, IB = 0.6 Adc)		CE(Sat)	_	1.0	
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)			-	5.0	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc, T <sub>C</sub> = 100°C)			-	2.0	S. 881 13/61
Base-Emitter Saturation Voltage		VBE(sat)			Vdc
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc)	BS43 UNR	1 29/85A2 2N	ofmy <del>2</del>	1.4 gainsB	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc, T <sub>C</sub> = 100°C)	abV 001	19) 300	HGS5V	1.4 99010	rettern dage
DYNAMIC CHARACTERISTICS	50 Vdc	DSE tau	UX30V	Voltage	Y011-01 3-10
Current-Gain Bandwidth Product	SbV 088	fT	6.0	28 99830	MHz
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)		0.8	VER	500	Boxs Volt
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 MHz)	Ade	C <sub>ob</sub>	50	200	pF
	N/N D	0.2	100,00	117 xlask +	
SWITCHING CHARACTERISTICS	abA	0.0	18	Lugundne	D - tream
Resistive Load (Table 2)	50A		mo"	(1) Abi	
Delay Time		td	3 -	0.05	μs
(VCC 250 Vdc, IC 3.0 A,		tr		0.7	μs
B <sub>1</sub> = I <sub>B2</sub> = 0.6 A, t <sub>p</sub> = 100 μs			-	4.0	μs
Storage Time $I_{B1} = I_{B2} = 0.6 \text{ A, } t_p = 100 \mu\text{s}$		ts	-	001-11-9	
Storage Time $I_{B1} = I_{B2} = 0.6 \text{ A}, t_p = 100 \mu\text{s}$ Duty Cycle $\leq 2.0\%$ )	29.00	can tf	-	0.8	μs
Storage Time $ B_1  =  B_2  = 0.6 \text{ A}, t_p = 100 \mu \text{s}$ Duty Cycle $\leq 2.0\%$ )  Inductive Load, Clamped (Table 2)	30.00	t <sub>f</sub> Symbol	— Тур	Max	Unit
Fall Time $  B_1 =  B_2 = 0.6 \text{ A, } t_p = 100  \mu \text{S} $ $  B_1 =  B_2 = 0.6 \text{ A, } t_p = 100  \mu \text{A, } t_p = 100 \text$	ted V <sub>CEX</sub> ,	t <sub>f</sub> Symbol t <sub>sv</sub>	- Тур		Unit µs
Fall Time $  B  =$	ted V <sub>CEX</sub> ,	t <sub>f</sub> Symbol  t <sub>sv</sub> t <sub>c</sub>	— Тур	Max 4.0	Unit μs μs
Rise Time $   B_1 =   B_2 = 0.6 \text{ A, } t_p = 100 \text{ µs} $ $   Duty \text{ Cycle} \leq 2.0\% ) $ $   Storage \text{ Time} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $	ted V <sub>CEX</sub> , Vdc , T <sub>C</sub> = 100 <sup>o</sup> C)	t <sub>f</sub> Symbol  t <sub>sv</sub> t <sub>c</sub> t <sub>fi</sub>	- Тур - 0.6	Max 4.0 — 0.8	Unit μs μs μs
Rise Time $   B_1 =   B_2 = 0.6 \text{ A, } t_p = 100  \mu \text{s} $ $   Duty \ Cycle \leq 2.0\% ) $ $   Storage \ Time $ $   (I_C = 3.0 \ A(pk), \ V_{clamp} = Ra $ $   B_1 = 0.6 \ A, \ V_{BE}(off) = 5.0  V_{BE}(off) = 1.00  \mu \text{s} $ $   C_{COSSOVET} \ Time $	ted V <sub>CEX</sub> , Vdc , T <sub>C</sub> = 100°C)	tf Symbol tsv tc tfi tsv	— Тур — 0.6 — 0.8	Max 4.0	Unit μs μs μs μs
Rise Time $   B_1 =   B_2 = 0.6 \text{ A, } t_p = 100 \text{ µs} $ $   Duty \text{ Cycle} \leq 2.0\% ) $ $   Storage \text{ Time} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $ $   ICC = 3.0 \text{ A(pk)}, \text{ V}_{clamp} = \text{Ra} $	ted V <sub>CEX</sub> , Vdc , T <sub>C</sub> = 100°C)	tf Symbol tsv tc tfi	- Тур - 0.6	Max 4.0 — 0.8	Unit μs μs μs

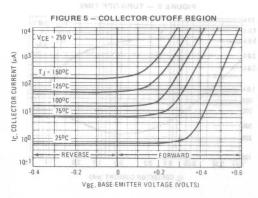
#### BY ON BEING THE PROPERTY OF CHARACTERISTICS THE MENTING MEACHING THE BUILDING THE B











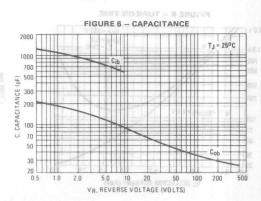


FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS TO A RANGE OF SWITCHING TIMES NOTE

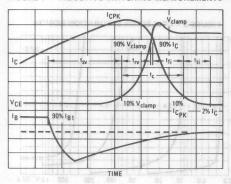


TABLE 1 - INDUCTIVE SWITCHING PERFORMANCE

IC (A)	TC °C	t <sub>sv</sub> μs	t <sub>rv</sub> μs	tfi μs	t <sub>ti</sub> μs	t <sub>c</sub>
1.0	25	0.70	0.22	0.21	0.23	0.66
	100	1.20	0.37	0.19	0.39	0.95
3.0	25	1.10	0.09	0.12	0.08	0.29
	100	1.60	0.42	0.19	0.40	1.01
5.0	25	1.10	0.16	0.19	0.11	0.46
	100	1.70	0.45	0.37	0.26	1.08

Note: All Data Recorded in the Inductive Switching Circuit Shown in Table 2.

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC.

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

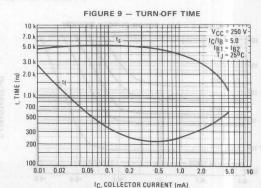
PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv} + t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

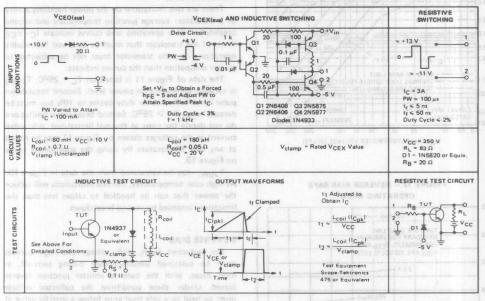
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are quaranteed at 100°C.

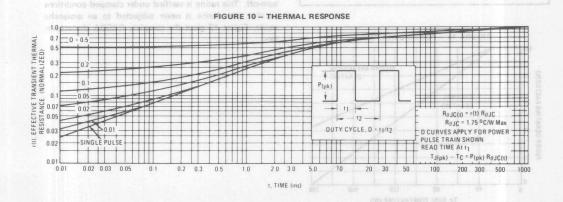
#### RESISTIVE SWITCHING PERFORMANCE

FIGURE 8 - TURN-ON TIME VCC = 250 V 1.0 700 500 **€** 300 ₩ 200 td @ VBE(off) = 5.0 V 100 70 50 30 20 0.05 0.1 0.2 IC, COLLECTOR CURRENT (AMP)

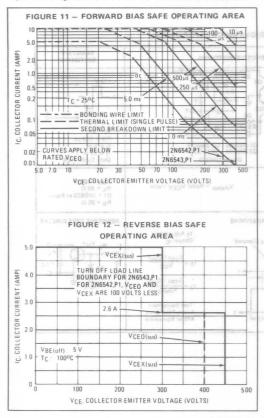


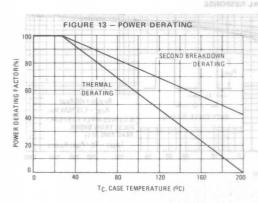






The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.





#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on  $T_C = 25^{o}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

TJ(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode, Figure 12 gives the complete RBSOA characteristics,



#### **Designers Data Sheet**

#### SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The 2N6544 and 2N6545 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for 115 and 220 volt line operated switch-mode applications such as:

- Switching Regulators
- PWM Inverters and Motor Controls
- Solenoid and Relay Drivers
- Deflection Circuits

Specification Features -

High Temperature Performance Specified for: Reversed Biased SOA with Inductive Loads

Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

#### \*MAXIMUM RATINGS

Rating	Symbol	2N6544	2N6545	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	350	450	Vdc
Collector-Emitter Voltage	VCEV	650	850	Vdc
Emitter Base Voltage	VEB	9	.0	Vdc
Collector Current — Continuous — Peak (1)	Ic ICM		.0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	8.0 16		Adc
Emitter Current — Continuous — Peak (1)	IE IEM	16 32		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	125 71.5 0.714		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	°C/W
Maximum Lead Temperature for Soldering	TL	275	°C

\*Indicates JEDEC Registered Data

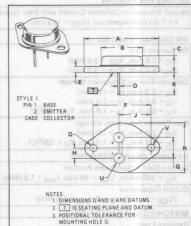
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 8 AMPERE NPN SILICON POWER TRANSISTORS

300 and 400 VOLTS 125 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case"



♦ • 13 (0.005) · T V · FOR LEADS:

♦ 0.13 (0.005) W T V W Q W 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIN	METERS	INC	HES	
MID	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
B	Ven E	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30,15 BSC		1.187 BSC		
G	10.92	BSC	0.430 BSC		
Н	5.48	BSC	0.215 BSC		
J	16.85	BSC	0.66	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
V	3.81	4.19	0.150	0.165	

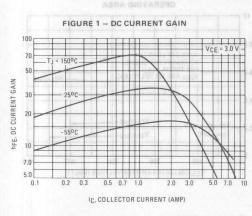


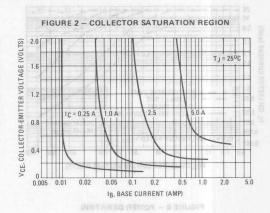
	ARACTERISTICS (T <sub>C</sub> = 25°C Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERIS	STICS (1)					
Collector-Emitter Sus	taining Voltage		VCEO(sus)	2 300MH	SWITC	Vdc
(Ic = 100 mA, IB	= 0)	2N6544	PHEISTORI	300	NPN SILICON	
		2N6545	TATO I REPORTED	400	10012101011	
Collector-Emitter Sus	taining Voltage	ageillov-rtgr	VCEX(sus)	transistors are	544 and 211654	Vdc
(IC = 4.5 A, V <sub>clan</sub>	np = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C)	2N6544	cinculits where	350	power svitchin	
	O s' langues O	2N6545	115 and 220 m	450	ely and particula	
(IC = 8.0 A, V <sub>clan</sub>	np = Rated V <sub>CEO</sub> -100 V,	2N6544		200	ch-mode <del>s</del> pplica	
$T_C = 100^{\circ}C$	The Designers El	2N6545		300	-	
Collector Cutoff Curr	ent mplants arty arism	1	CEV		a Regulators	mAdc
	alue, VBE (off) = 1.5 Vdc)			Controls	0.5	
(VCEV = Rated V	alue, VBE (off) = 1.5 Vdc, TC = 1	00°C)	A	-	2.5	alamata di sa
Collector Cutoff Curr		- 10 7	CER	-	3.0	mAdc
(VCE = Rated VC	EV, $R_{BE} = 50 \Omega$ , $T_{C} = 100^{\circ}C$ )				on Circuits	b Defineria
Emitter Cutoff Curre		9	1EBO	_	1.0	mAdc
(VEB = 9.0 Vdc, I			,ERO	mance Specifie	aperature Perfor	
SECOND BREAKDO			7 O stee		New AG2 beasild to	
	ollector Current with base forwar	d bigged	Lan	0.2		
	etitive) (V <sub>CE</sub> = 100 Vdc)	d blased	<sup>1</sup> S/b	2050 0.2	ni-driv <del>-</del> zomiT p	Adc
	184-4711				zegatio V o	Manuta.
ON CHARACTERIS	TICS (1)				Currants	ensuise I
DC Current Gain (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 3.0 Vdc)			pEE	12	60	_
(IC = 5.0 Adc, VC				7.0	35	
Collector-Emitter Sat			Vest	7.0	33	Vdc
(IC = 5.0 Adc, IB	and the second s		VCE (sat)	_	1.5	Vac
(IC = 8.0 Adc, IB				_	5.0	
	= 1.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)			_		AS MUMBA
Base-Emitter Saturat		Wall   Elegate	VBE(sat)	Svet	gnitas	Vdc
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub>			00E (Sd1)	Janey -	1.6	V rettim 3-a
	= 1.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)		086 1	Tan V	1.6	
DYNAMIC CHARAC		nso Voc	G28 1 V	anV T	906110	V rettication
Current-Gain - Band		obv. T	fT	T 6.0	28	MHz
	V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)			0.0	tupunitned	2
Output Capacitance	CE 10 too, lest 110 miles	2000	Cob	75	300	pF
	E = 0, f <sub>test</sub> = 1.0 MHz)		ODD	/5	300	rrent - Can
SWITCHING CHARA	DAY STANDARD OF THE STANDARD O	200	1 1	unt .	(f)	less -
Resistive Load	3 JUN DRITHLOW	Aude	81	11	continuous	3 - InemaS
Delay Time	STRUCTURE 1			B	0.05	
	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A,		t <sub>d</sub>			μs
Rise Time	$I_{B1} = I_{B2} = 1.0 \text{ A}, t_p = 100 \mu s,$		t <sub>r</sub>		1.0	μs
Storage Time	Duty Cycle ≤ 2.0%)		ts	-	4.0	μs
Fall Time		52 1 500	tf	1	1.0	μs
Inductive Load, Clan	nped				007	and the same
Storage Time	(IC = 5.0 A(pk), V <sub>clamp</sub> = Rated		ts		4.0	μs
Fall Time	IB1 = 1.0 A, VBE(off) = 5.0 Vd	c, T <sub>C</sub> = 100°C)	tf		0.9	μs
CAC DE SECO	TWO THE THE	1000		Ту	pical	
Storage Time	(IC = 5.0 A(pk), V <sub>clamp</sub> = Rate	d VCEX,	ts		1.2	μs
Fall Time	IB1 = 1.0 A, VBE(off) = 5.0 Vd		tf	1	0.18	μς

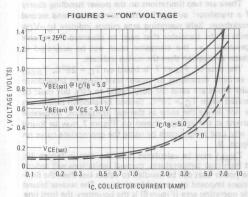
(1) Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

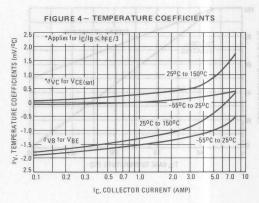
\*Indicates JEDEC Registered Data.

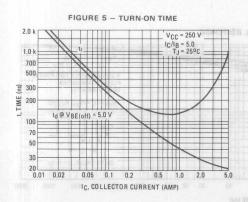
#### STAR 2AIS SERSYSS - 8 SRUDIS DC CHARACTERISTICS A DWITARS OF STAR 2AIS GRAMSON - Y ESUDIS

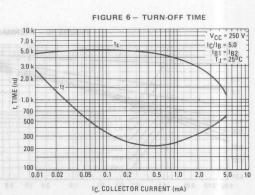




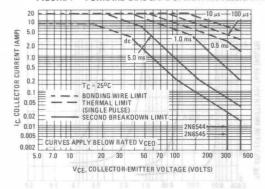




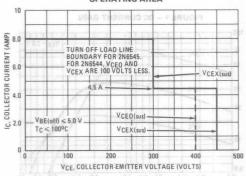




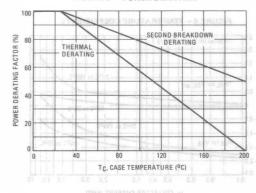




## **OPERATING AREA**



#### FIGURE 9 - POWER DERATING

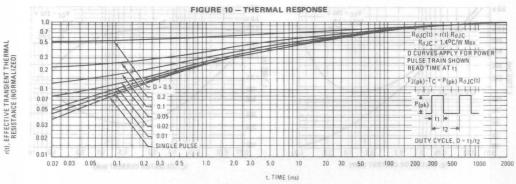


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on Tc = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on lFigure 7, may be found at any case temperature by using the appropriate curve on Figure 9.

TJ(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. The reverse biased safe operating area (Figure 8) is the boundary the load line may traverse during turn-off.







#### **Designers Data Sheet**

## SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The 2N6546 and 2N6547 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for 115 and 220 volt line operated switch-mode applications such as:

- Switching Regulators
- PWM Inverters and Motor Controls
- Solenoid and Relay Drivers
- Deflection Circuits

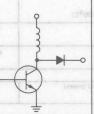
Specification Features -

High Temperature Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents



#### \*MAXIMUM RATINGS

Rating	Symbol	2N6546	2N6547	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	350	450	Vdc
Collector-Emitter Voltage	VCEV	650	850	Vdc
Emitter Base Voltage	VEB	9	.0	Vdc
Collector Current — Continuous — Peak (1)	IC ICM		5 0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		0	Adc
Emitter Current — Continuous — Peak (1)	IE IEM		5 0	Adc
Total Power Dissipation @ $T_{C} = 25^{\circ}C$ @ $T_{C} = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	11 10	75 00 .0	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	ŤL	275	°C

\*Indicates JEDEC Registered Data

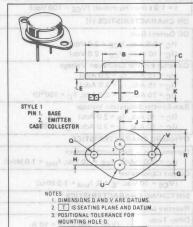
(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

#### 15 AMPERE NPN SILICON POWER TRANSISTORS

300 and 400 VOLTS (001 - 51)

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



- DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIN	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
8		21.08		0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15	BSC	1,187 BSC		
G	10.92	BSC	0.430 BSC		
Н	5.46	BSC	0.215 BSC		
1	16.89	BSC	0.665	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

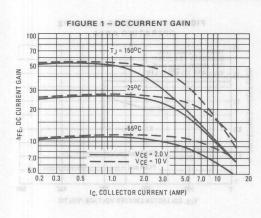
CASE 1-05 TO-204AA 2N6547

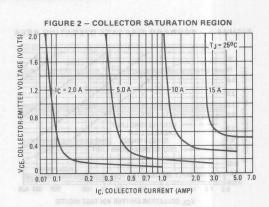


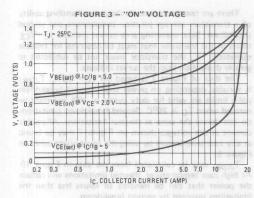
	Characteristic		Symbol	Min	Max	Unit
OFF CHARACTE	RISTICS (1)					
	Sustaining Voltage I <sub>B</sub> = 0)	2N6546 2N6547	VCEO (sus)		SWITCH PN SHEICON	Vdc
Collector-Emitter S			VCEX(sus)	ALL DESCRIPTION	FRUGILIE ET	Vdc
	lamp = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C)	2N6546 2N6547	nariw atiugala		546 and 2N66d power switchie	The 2NS
(I <sub>C</sub> = 15 A, V <sub>cl</sub> T <sub>C</sub> = 100	amp = Rated V <sub>CEO</sub> - 100 V, OC)	2N6546 2N6547	115 and 220	The second second second	y are particule h-mode <del>a</del> pphos	
	urrent I Value, VBE(off) = 1.5 Vdc) I Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 10	10°C)	CEV	- Controls	2101.01upsR g	
Collector Cutoff C (VCE = Rated )	urrent VCEV, R <sub>BE</sub> = 50 $\Omega$ , T <sub>C</sub> = 100°C)	1	ICER	279	and S.O.A bas	mAdc
Emitter Cutoff Cut (VEB = 9.0 Vdd	rrent c, IC = 0)	0-10-1	IEBO	-	0.1 Deptures —	mAdc
SECOND BREAKE	DOWN	179	101101	Historica Spinster	iproduce Period	pro r. citi. ci
	Collector Current with base forward epetitive) (VCE = 100 Vdc)	biased	IS/b	absol switch	en AU <u>S</u> been 5 of fines with te	Adc
ON CHARACTER	ISTICS (1)				n Voltages	Saturatio
DC Current Gain (I <sub>C</sub> = 5.0 Adc, (I <sub>C</sub> = 10 Adc,	V <sub>CE</sub> = 2.0 Vdc) V <sub>CE</sub> = 2.0 Vdc)		hFE	12 6.0	60 30	Lakeje
Collector-Emitter S (I <sub>C</sub> = 10 Adc, I (I <sub>C</sub> = 15 Adc, I (I <sub>C</sub> = 10 Adc, I	B = 2.0 Adc)		VCE (sat)	-	1.5 5.0 2.5	Vdc
Base-Emitter Satur	The second secon	ants I commer	VBE(sat)		1.6 gainst	Vdc
(IC = 10 Adc,	I <sub>B</sub> = 2.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C		000	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.6	
DYNAMIC CHAR	ACTERISTICS	- LV 1 844	Dac I			
Current-Gain — Ba (I <sub>C</sub> = 500 mAd	ndwidth Product c, VCE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	850 Vdc	oadT v	6.0	28	MHz
Output Capacitano (V <sub>CB</sub> = 10 Vdc	e, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 MHz)	Ade	Cob	125	500 Zyounitno(	pF ) — manual m
SWITCHING CHA	RACTERISTICS	And I	Or The State of th		T110101	tena a toma
Resistive Load	A THE SEATING PLANE A		05. 6	iga i	(1)	- Pesk
Delay Time	(V <sub>CC</sub> = 250 V, I <sub>C</sub> = 10 A,	sbA .	t <sub>d</sub>	N. T	0.05	0 - 1 MS 100
Rise Time	$I_{B1} = I_{B2} = 2.0 \text{ A}, t_0 = 100 \mu\text{s},$		t <sub>r</sub>	17 ±	1.0 (f) xes	9 — μs
Storage Time	Duty Cycle ≤ 2.0%)		t <sub>s</sub>	9 +	3-8.4.0 T @ no	Teches Mesterno
Fall Time	L.Comment of L.	1	Of t <sub>f</sub>	+	0.7	μs
Inductive Load, CI	amped the Abeviller	O W	1:1			GA SYUGH ST
Storage Time	(I <sub>C</sub> = 10 A(pk), V <sub>clamp</sub> = Rated V <sub>C</sub>	CEX, IB1 = 2.0 A,	er da-t <sub>s</sub>	1.7.	5.0 (5) (1) (4)	μs
Fall Time	VBE(off) = 5.0 Vdc, T <sub>C</sub> = 100°C)		tf	±	1.5	μѕ
1000				Тур	pical	MAL DISSULA
Storage Time	(I <sub>C</sub> = 10 A(pk), V <sub>clamp</sub> = Rated V	CEX. B1 = 2.0 A,	t <sub>s</sub> lean	2	.0 pilantisa	μs
Fall Time	VBE(off) = 5.0 Vdc, TC = 25°C)	W/O*   0.	tf	0.	09	μs

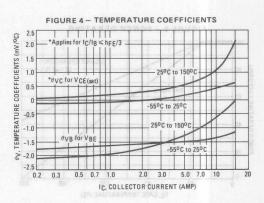
(1) Puse Test: Pulse Width = 300 µs, Duty Cycle = 2%.

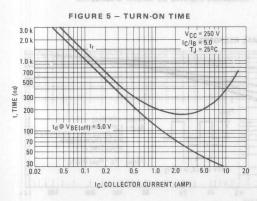
#### TYPICAL ELECTRICAL CHARACTERISTICS

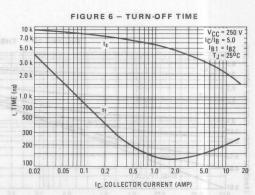




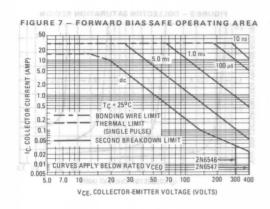


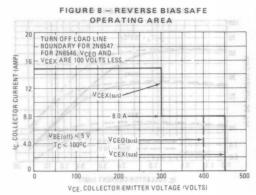


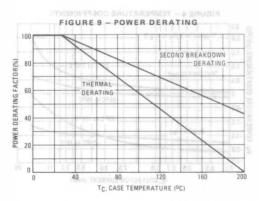




#### MAXIMUM RATED SAFE OPERATING AREAS



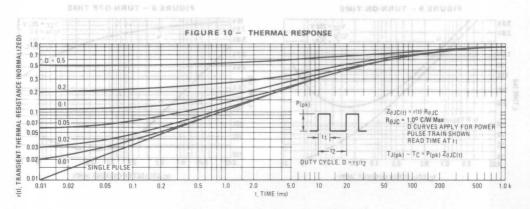




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on  $T_C$  = 25°C;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 7 may be found at any case temperature by using the appropriate curve on Figure 9.

 $T_{J(pk)}$  may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





#### NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for amplifier and driver applications where high gain is an essential requirement, low power lamp and relay drivers and power drivers for high-current applications such as voltage regulators.

· High DC Current Gain -

hFE = 25,000 (Min) @ I<sub>C</sub> = 200 mAdc - 2N6548 = 15,000 (Min) @ I<sub>C</sub> = 500 mAdc - 2N6548

 Collector-Emitter Breakdown Voltage -BVCES = 40 Vdc (Min) @ IC = 100 μAdc

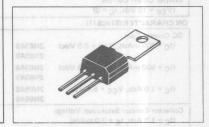
 Low Collector-Emitter Saturation Voltage -VCE(sat) = 1.5 Vdc (Max) @ IC = 1.0 Adc

 Duowatt Package – 2 Watts Free Air Dissipation @ TA = 25°C

#### DUOWATT

NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

(Vcs = 10 Vdc, 1c = 0)



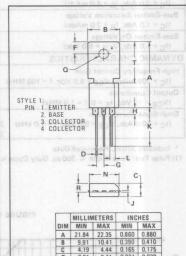
#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	VCEO	40	Vdc
Collector-Emitter Voltage 050 05	VCES	40	Vdc 38
*Collector-Base Voltage 000,31	VCBO	50	Vdc
*Emitter-Base Voltage	VEBO	12	Vdc
*Collector Current - Continuous	1c	2.0	Adc
*Base Current — Continuous	I <sub>B</sub>	100	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0	Watts mW/ <sup>O</sup> C
Total Power Dissipation@T <sub>C</sub> = 25°C  Derate above 25°C  ABRA	PD	10	Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C
* Solder Temperature, 1/16" from Case for	-	260	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Thermal Resistance, Junction to Case	ReJC	12.5	°C/W

\*Indicates JEDEC Registered Data. calculated from the date in Figure 6. At high class remove sturies



1	MILLIN	ETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.19	4.44	0.165	0.175	
D	0.61	0.71	0.024	0.028	
F	3.68	3.94	0.145	0.155	
G	2.41	2.67	0.095	0.105	
H	1.70	1.96	0.067	0.077	
J	0.48	0.66	0.019	0.026	
K	12.70	22.7	0.500		
L	1.78	2.03	0.070	0.080	
N	9.91	10.16	0.390	0.400	
Q	3.56	3.81	0.140	0.150	
R	2.41	2.67	0.095	0.105	
T	13.21	13.97	0.520	0.550	

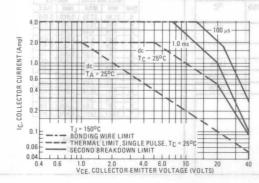
CASE 306-04 TO-202AC

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 µAdc, V <sub>BE</sub> = 0)		BVCES	40 LRAG MOS	Nen sit	Vdc
Collector-Base Breakdown Voltage (IC = 100 µAdc, IE = 0)		BVCBO	2MA 50 931	AMPLIF	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 μAdc, I <sub>C</sub> = 0)	inyers and	BVEBO	12	requirement	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0)	Zioreiopo	СВО	enova zeruda ivi	100 - mad tremu	nAdc
Emitter Cutoff Current (VEB = 10 Vdc, IC = 0)		IEBO	9 IC = 200 mA 9 IC = 500 mA	15,000 (Mint	nAdc
ON CHARACTERISTICS (1)			- sparioV nyrot	Emitter Breako	- Ceilector
DC Current Gain (IC = 200 mAdc, VCE = 5.0 Vdc) (IC = 500 mAdc, VCE = 5.0 Vdc) (IC = 500 mAdc, VCE = 5.0 Vdc) (IC = 1.0 Adc, VCE = 5.0 Vdc) 2N6548 2N6549		hee shad o Ade	25,000 15,000 15,000	150,000 150,000 - - -	Levy Coll VCE(s
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 4.0 mAdc)		VCE(sat)	_	1.5 2.0	Vdc
Base-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 2.0 mAdc)		V <sub>BE(sat)</sub>	-	2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		V <sub>BE</sub> (on)	-	2.0	Vdc
DYNAMIC CHARACTERISTICS					
High Frequency Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)	)	Ihfel	1.0	- 204	TAS MUMB
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	pinU Unit	Cop		7.0	pF
Small-Signal Current Gain (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 kHz)	2N6548 2N6549	Voss A	20,000	/ orteage _	reptim 3-notes

\* Indicates JEDEC Registered Data (1) Pulse Test: Pulse Width  $\leq 300~\mu s$ , Duty Cycle  $\leq 2.0\%$ 

#### TYPICAL CHARACTERISTICS

#### FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA



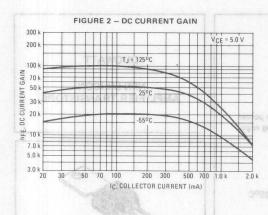
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

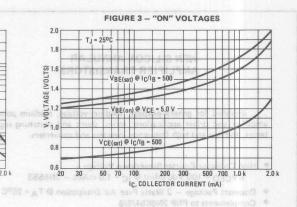
The data of Figure 1 is based on  $TJ_{(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ_{(pk)} \leqslant 150^{\circ}C$ .  $TJ_{(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

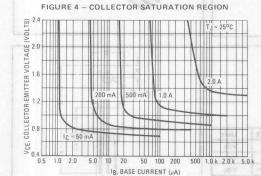
3

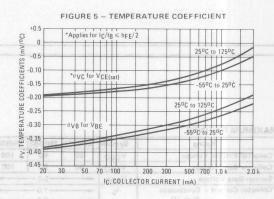


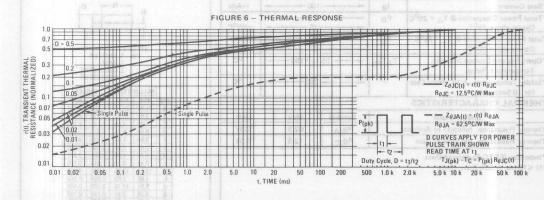
#### TYPICAL CHARACTERISTICS (continued)













TYPICAL CHARACTERISTICS Instituted

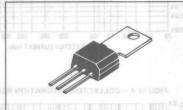
## NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc 2N6553
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to PNP 2N6554/5/6



NPN SILICON AMPLIFIER TRANSISTORS



GURES - TEMPERATURE COEFFICIEN I

MAXIMUM BATINGS

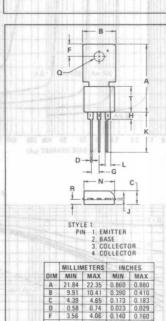
IVIAXIIVIOIVI NATIIVGS	The same of the sa			-20	
Rating	Symbol	2N6551	2N6552	2N6553	Unit
*Collector-Emitter Voltage	VCEO	60	80	100	Vdc
*Collector-Base Voltage	VCBO	60	80	100	Vdc
*Emitter-Base Voltage	VEBO	-	<del></del> 5.0	-	Vdc
*Collector Current — Continuous — Peak (1)	lC	-	1.0 2.0		Adc
*Base Current	1 <sub>B</sub>	-	<del></del>	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	- 10	2.0 16		Watts mW/OC
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		—10— —80—		Watts mW/OC
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-55 to +15	50 ——	°C
*Solder Temperature, 1/16" from Case	To be	-	<u>260</u>	-	°C

THERMAL CHARACTERISTICS
-------------------------

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	Rejc	12.5	oc/M

\*Indicates JEDEC Registered Data.

(1) ≤10 ms, ≤ 50% Duty Cycle



	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.07.7
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

CASE 306-04 TO-202AC

3

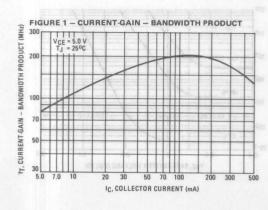
#### \*ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.)

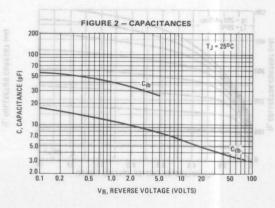
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS		THE THE PERSON NAMED IN		noine Till	
Collector-Emitter Breakdown Voltage		BVCEO			Vdc
(IC = 1.0 mAdc, IB = 0)	2N6551	8.0	60		
	2N6552		80	1754-174 II	
	2N6553		100	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
Collector-Base Breakdown Voltage	DV @ Inc 38V	BVCBO	Zeronik.		Vdc
(IC = 100 µAdc, IE = 0)	2N6551	\$ 1 HHT-D	60		
	2N6552	and MILLIAN	80		
	2N6553	1 S HI-FIN	100	Harry Hall	
Emitter-Base Breakdown Voltage		BVEBO	5.0		Vdc
(I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)		0.2			
Collector Cutoff Current	11 S 2 V	СВО			nAdc
(V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	2N6551	MILL MILL	- 11-11-11-1	100	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	2N6552	1 /0.1 002	605 00r 88	100	
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N6553		(Red Vitter	100	
Emitter Cutoff Current		IEBO	-	100	nAdc
(VEB = 4.0 Vdc, IC = 0)					
ON CHARACTERISTICS (1)	HAGIARE S TEMPERA		SIDER HOLTAN	UTAR SOTOR L	no kam
DC Current Gain		pEE			-
(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc)			60	TITLE I SIM	
(IC = 50 mAdc, VCE = 1.0 Vdc)		-3485 - IT-	80	300	
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc)		0.0 \$ 0.5	60		
(IC = 500 mAdc, VCE = 1.0 Vdc)	(HI J30A tot 0Au.		25	THE	
Collector-Emitter Saturation Voltage		VCE(sat)	HITTE TO THE		Vdc
(I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc)				0.5	
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)		2.0- #		1.0	
Base-Emitter On Voltage		VBE(on)	HUNTER FOR	1.2	Vdc
$(I_C = 250 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc})$					
DYNAMIC CHARACTERISTICS		a 1 - 5 - 14 - 15			
Current-Gain - Bandwidth Product	58 V 101 BVD	f <sub>T</sub>	75	375	MHz
$(I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f$	= 20 MHz)	RS- 7	HART IN	MILL II HU	
Collector-Base Capacitance		C <sub>cb</sub>	BITTE IT TO	18	pF
(VCB = 20 Vdc, IE = 0, f = 1.0 MH	z)	0.00 0.00	7 02 00 02	B.2 B.5 B.5	

\* Indicates JEDEC Registered Data

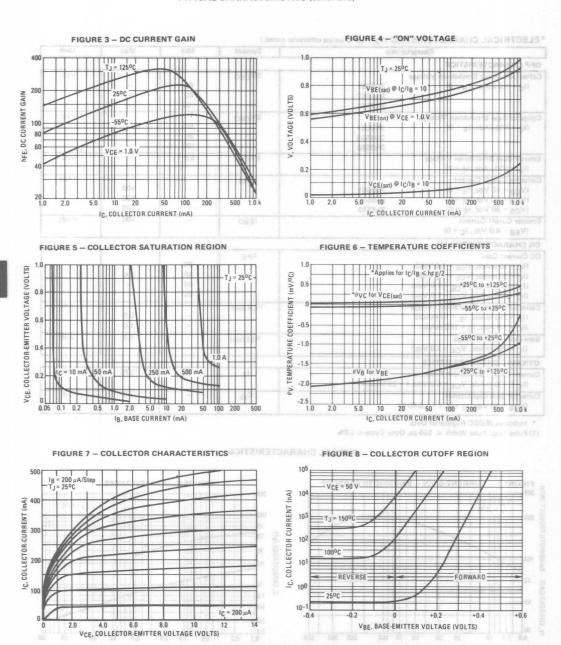
(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%

#### MONDER RROTUS NOTOS 1100 - TYPICAL CHARACTERISTICS SOFTEM STOMARMO NOTOS 1100 - C SAUSIFI





#### TYPICAL CHARACTERISTICS (continued)



# M MOTOROLA

#### TYPICAL CHARACTERISTICS (continued)

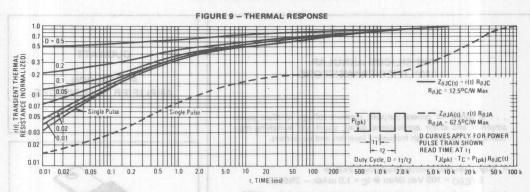
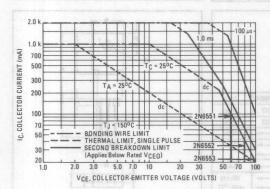


FIGURE 10 - ACTIVE-REGION SAFE-OPERATING AREA

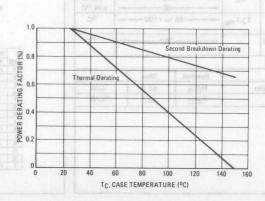


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 10 is based on  $T_C=25^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

TJ(pk) may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.







CVEICAL CHARACTERISTICS (continued)

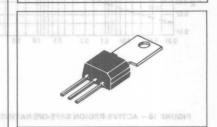
## PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc 2N6556
- Duowatt Package − 2 Watts Free Air Dissipation @ T<sub>A</sub> = 25°C
- Complements to NPN 2N6551/2/3



AMPLIFIER TRANSISTORS



here are two limitations on the power handling ability

operation; i.e., the translator must not be subjected greater distipation than the curves indicate.

The data of Figure 10 is based on Tig. = 25°C. Tutp.

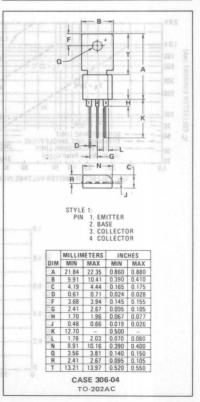
MAXIMUM RATINGS mill lemserly as emiss arts statish for ob-

briper sd Rating stupie no m	Symbol	2N6554	2N6555	2N6556	Unit
*Collector-Emitter Voltage	VCEO	60	80	100	Vdc
*Collector-Base Voltage	VCBO	60	80	100	Vdc
*Emitter-Base Voltage	VEBO	contract state	<del></del>	-	Vdc
*Collector Current — Continuous Peak	lc lc	o tent t	—1.0— —2.0—		Adc
*Base Current	IB	an resignation to	<del></del>	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	-	2.0 <i>-</i>	-	Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	P <sub>D</sub>	207	—10— —80—	STAMUS -	Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-55 to +15	60 —	°C
*Solder Temperature, 1/16" from Case for 10 Seconds	political	G metalerel	—260 —	-	°c

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	Rejc	12.5	°C/W

\*Indicates JEDEC Registered Data.



Characteri	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	2N6554 2N6555 2N6556	BVCEO	60 80 100	MRUO DO — \$ 3 1981 - (T           1	Vdc
Collector-Base Breakdown Voltage $(I_C = 100 \mu\text{Adc}, I_E = 0)$	2N6554 2N6555 2N6556	BVCBO	60 80 100	35 es	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)	No.	BVEBO	5.0		Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N6554 2N6555 2N6556	ICBO		100 100 100	nAdc
Emitter Cutoff Current (VEB = 4.0 Vdc, I <sub>C</sub> = 0)	80 0,0 D,S 0.1	IEBO	305 H01 Op	100	nAdc 10
ON CHARACTERISTICS (1)	3390 (3)		(Am) TUSHRUS	1C. COLCECTOR	
DC Current Gain (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	FIGURE 5 - TEMP	hFE MO	60 80 60 25	_ 300 NS ROTABIJOS	PIGURE 4
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)	(m) 35V rol 3Ver 2	VCE(sat)	-	0.5 1.0	Vdc
Base-Emitter On Voltage (IC = 250 mAdc, VCE = 5.0 Vdc)	*Applies for fortiging legs/ 2	V <sub>BE</sub> (on)		1.2	Vdc 8.0
DYNAMIC CHARACTERISTICS		Day 1	his / - i i ikin		
Current-Gain — Bandwidth Product (IC = 100 mAdc, VCE = 5.0 Vdc, f =		fT -	75	375	MHz
Collector-Base Capacitance (V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	387 101 8000	C <sub>cb</sub>	44	/ 18	pF

<sup>\*</sup> Indicates JEDEC Registered Data.

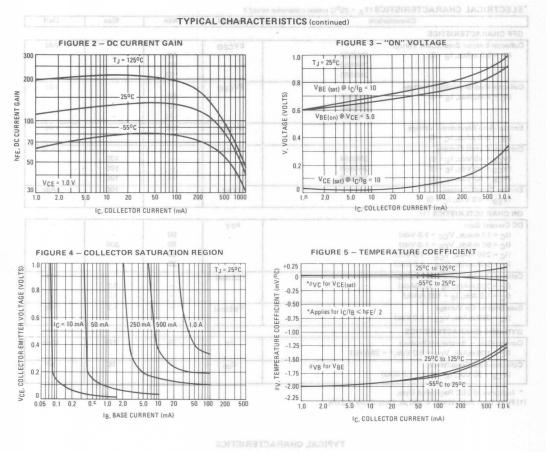
#### TYPICAL CHARACTERISTICS

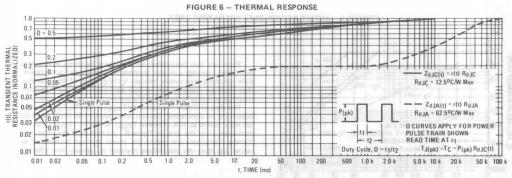
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_J(pk) = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leqslant 150^{\circ}C$ .  $T_J(pk)$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

<sup>(1)</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.







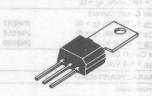
## NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

. . . designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage BVGEO = 350 Vdc (Min) @ IC = 1.0 mAdc 2N6559
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.6 Vdc (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance —
   C<sub>cb</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 20 Vdc
- Duowatt Package –
   2 Watts Free Air Dissipation @ TA = 25°C



NPN SILICON AMPLIFIER TRANSISTORS



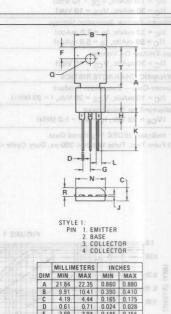
#### MAXIMUM RATINGS

maximom marinedo					
Rating	Symbol	2N6557	2N6558	2N6559	Unit
*Collector-Emitter Voltage	VCEO	250	300	350	Vdc
*Collector-Base Voltage	VCBO	250	300	350	Vdc
*Emitter-Base Voltage	VEBO	4	— 6.0 <del>—</del>	-	Vdc
*Collector Current - Continuous Peak	lc	-	0.5 0.7	<b>-</b>	Adc
*Base Current	IB	-	<del></del>	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	-	2.0 16	-	Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	-	— 10 — — 80 —	TOATA	Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-55 to +15	0	°C
*Solder Temperature, 1/16" from Case	-	4	— 260 —	-	°C

#### THERMAL CHARACTERISTICS

Characteristic of market	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

\*Indicates JEDEC Registered Data.



A	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.19	4.44	0.165	0.175
D	0.61	0.71	0.024	0.028
F	3.68	3.94	0.145	0.155
G	2.41	2.67	0.035	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.70	1.0783	0.500	
L	1.78	2.03	0.070	0.080
N	9.91	10.16	0.390	0.400
Q	3.56	3.81	0.140	0.150
R	2.41	2.67	0.095	0.105
T	13.21	13.97	0.520	0.550
		ASE 30	101.0101	

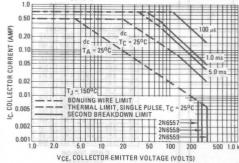
3



Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS	1		ILAR	ICON ANNU	NPN SIL	
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0) 2N6558 2N6558 2N6559		SHC	BVCEO	250 300 350	VOLTAGE	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0) 2N6557 2N6558 2N6559				300 350		
Emitter-Base Breakdown Voltage (IE = 100 µAdc, IC = 0)		61	BV <sub>EBO</sub>		stor-Eimitter B = 350 Vdc (M	
Collector Cutoff Current (VCB = 150 Vdc, IE = 0) 2N6557 (VCB = 200 Vdc, IE = 0) 2N6558 (VCB = 250 Vdc, IE = 0) 2N6559			ICBO _ a	turation Volta ext) © <u>1</u> C = 30	ctor-Emitter Sa	μAdc e
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			IEBO	VCB = 20 V60	(x 0.1 3 0.	μAdc
ON CHARACTERISTICS(1)			2008	ation @ To = 2	Free Air Dissip	2 Watts
DC Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)			hFE	25 40	180	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc) (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 5.0 mAdc)			VCE(sat)	-	0.6 1.5	Vdc
Base-Emitter On Voltage (IC = 30 mAdc, VCE = 10 Vdc)			V <sub>BE</sub> (on)	-	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (IC = 10 mAdc, VCE = 20 Vdc, f = 20 MHz)			fT	45	200	MHz MYAR MUMI
Collector-Base Capacitance (V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	Unit	085 085 085 085	C <sub>cb</sub>	Symbol 294s	3.0	pF
* Indicates JEDEC Registered Data.	Vdo	350	300 0	Vego 25	5087	ov sett ellerote cror-fissa Voltag

### TYPICAL CHARACTERISTICS

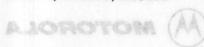
#### FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA

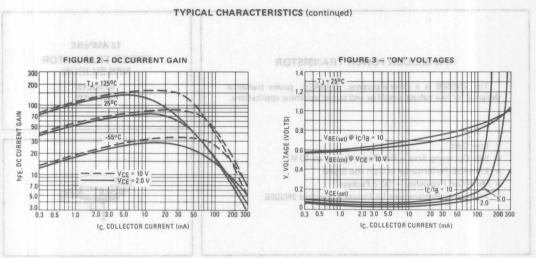


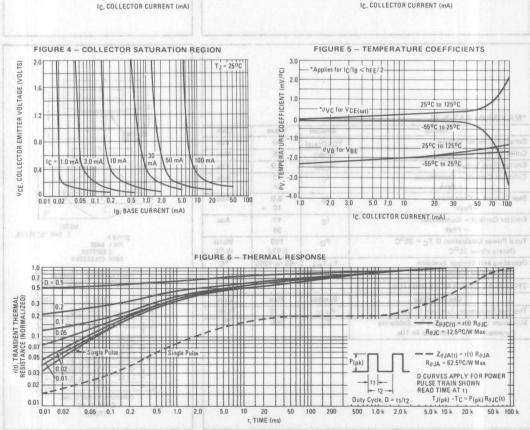
(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.









#### NPN SILICON POWER TRANSISTOR

The 2N6569 is a general-purpose, EPIBASE power transistor designed for low voltage amplifier and power switching applications.

- Low Cost
- Safe Operating Area Full Power Rating to 40 V
- EPIBASE Performance in Gain and Speed
- Metal Can Reliability TO-3 Package
- All-Purpose Replacement for Industry Standard 2N3055

12 AMPERE

POWER TRANSISTOR
NPN SILICON

40 VOLTS 100 WATTS



3

#### 

Vdc Emitter-Base Voltage Vdc Collector Current - Continuous 12 Adc - Peak 24 Base Current - Continuous 5.0 Adc IB - Peak 10 . 17 Emitter Current - Continuous 1E Adc - Peak 34 Total Power Dissipation @ T<sub>C</sub> = 25°C 100 Watts PD W/OC Derate above 25°C 0.572

Operating and Storage Junction Temperature Range

THERMAL CHARACTERISTICS			
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/16" from Case fo 10s.	TL	265	°С

 $T_{J}$ , $T_{stg}$ 

-65 to +200

NOTE:
STYLE1:
1. DIM "Q" IS DIA.
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM A B C D E F G H J	MILLI	METERS	INCHES		
	MIN	MAX	MIN	MAX	
A		39.37		1.550	
В	1-	21.08	1 -	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	-	3.43	Sept. 3	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
Q	3.84	4.09	0.151	0.161	
R	-	26.67	THE	1.050	

CASE 11-01 (TO-3)

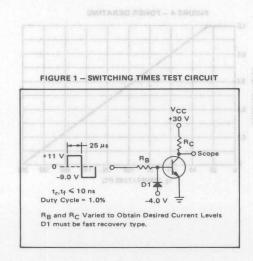
Unit

Vdc

°C

H 33,481	Characteristic	Symbol	Min	Max	Unit
OFF CHARACTE	RISTICS	The second			
Collector-Emitter		VCEO(sus)	40		Vdc
	urrent dc, V <sub>BE(off)</sub> = 1.5 Vdc) dc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100 <sup>o</sup> C)	ICEV		1.0	mAdo
Emitter Cutoff Cu (V <sub>EB</sub> = 5.0 Vd		IEBO		5.0	mAdd
SECOND BREAK	DOWN				Dispersion of
Second Breakdown Collector Current with Base Forward Biased (VCF = 40 Vdc, t = 1.0 s (non-repetitive))		ls/b	2.5		Adc
ON CHARACTER	ISTICS	605 p. 1	2.0	1.5 00.0	-
DC Current Gain (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 12 Adc, V <sub>CE</sub> = 4.0 Vdc)		hFE	15 5.0	200 100	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4,0 Adc, I <sub>B</sub> = 0.4 Adc) (I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 2.4 Adc)		VCE(sat)	1 1	1.5	Vdc
Base-Emitter Satur (I <sub>C</sub> = 4.0 Adc,		V <sub>BE</sub> (sat)	1000	2.0	Vdc
DYNAMIC CHAR	ACTERISTICS				
Current-Gain — Ba (I <sub>C</sub> = 1.0 Adc,	ndwidth Product V <sub>CE</sub> = 4.0 Vdc, f <sub>test</sub> = 0.5 MHz)	f <sub>T</sub>	1.5	15	MHz
Output Capacitance (VCR = 10 Vdc, I <sub>F</sub> = 0, f <sub>test</sub> = 1.0 MHz)		C <sub>ob</sub>	75	750	pF
SWITCHING CHAI	RACTERISTICS parego beating fol S angi 7 mont			batimi, i por	
Delay Time	(V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 0.2 Adc,	td	1 +	0.4	μs
Rise Time	t <sub>p</sub> = 25 μs, Duty Cycle ≤ 1.0%)	t <sub>r</sub>	1 -	1.5	μs
Storage Time	(V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.2 Adc,	as at <sub>s</sub>	UT 1	5.0	μs
Fall Time	t <sub>p</sub> = 25 μs, Duty Cycle ≤ 1.0%)	tf	VOLTAGE (VOLTS	1.5	μs

<sup>\*</sup>Indicates JEDEC Registered Data.





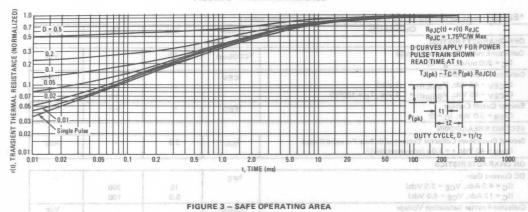
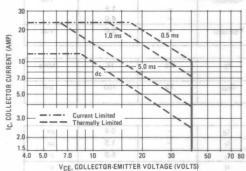


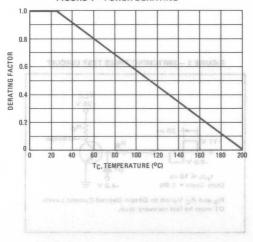
FIGURE 3 - SAFE OPERATING AREA



Safe operating area curves indicate IC-VCE limits of the transistor being observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. This transistor is thermally limited over its entire operation area. Figure 4 may be used to derate the curves shown or an effective  $R_{\theta JC(t)}$  may be computed from Figure 2 for pulsed operation.

11g = 4.0 Adc, 1g = 0.4 Add)

FIGURE 4 - POWER DERATING



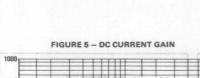
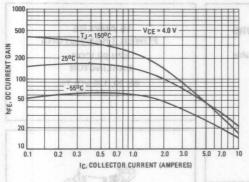
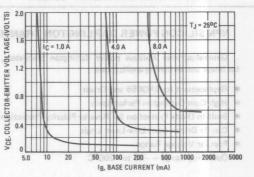
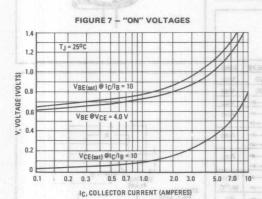
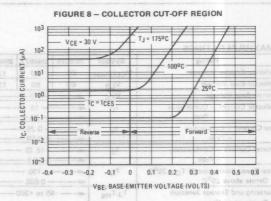


FIGURE 6 - COLLECTOR SATURATION REGION

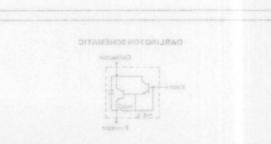












Symbol

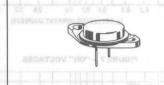


#### NPN SILICON POWER DARLINGTON TRANSISTORS

General-purpose EpiBase power darlington transistors, suitable for linear and switching applications.

- Replacement for 2N3055 and Driver
- High Gain Darlington Performance
- Built-In Diode Protection for Reverse Polarity Protection
- Can Be Driven from Low-Level Logic
- Popular Voltage Range
- Operating Range -65 to +200°C

15 AMPERE POWER TRANSISTORS NPN SILICON DARLINGTON 60, 90, 120 VOLTS 120 WATTS



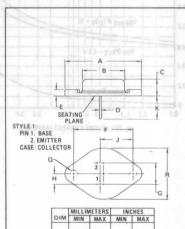
#### \*MAXIMUM RATINGS

Rating	Symbol	2N6576	2N6577	2N6578	Unit
Collector-Emitter Voltage	VCEO(sus)	60	90	120	Vdc
Collector-Base Voltage	VCB	60	90	120	Vdc
Emitter-Base Voltage	VEB	4	<del> 7.0</del>	-	Vdc
Collector Current - Continuous - Peak	l <sub>C</sub>	-	— 15 — — 30 —	<u></u>	Adc
Base Current - Continuous - Peak	1 <sub>B</sub>	4	— 0.25 — — 0.50 —	<u></u>	Adc
Emitter Current - Continuous - Peak	1 <sub>E</sub>	-	—15.25 — — 30.5 —	$\Rightarrow$	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4 10	120 0.685	-	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	65 to +200	0	°C

#### THERMAL CHARACTERISTICS

The state of the s						
Characteristic	Symbol	Max	Unit			
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.46	°C/W			
Maximum Lead Temperature for Soldering	TL	265	°C			

<sup>\*</sup>Indicates JEDEC Registered Data



	MILLEIN	MEIERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
В	-	22.23	-	0.875	
C	6.35	11.43	0.250	0.450	
D	0.97	1.09	0.038	0.043	
E	-	3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
Q	3.84	4.09	0.151	0.161	
R	-	26.67	-	1,050	

**CASE 11-03** TO-3

#### DARLINGTON SCHEMATIC



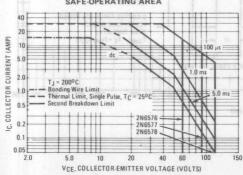
#### \*ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0) 2N6576 2N6577 2N6578	VCEO(sus)	60 90 120		Vdc
Collector Cutoff Current (VCE = Rated Value)	ICEO		1.0	mAdc
Collector Cutoff Current (VCER = Rated VCEO(sus) Value, RBE = 10 k $\Omega$ , TC = 150°C)	CER		5.0	mAdc
Collector Cutoff Current  VCEX = Rated VCEO(sus) Value, VBE(off) = 1.5 Vdc)	ICEV	-	5.0	mAdc
Collector Cutoff Current (V <sub>CB</sub> = Rated Value)	СВО	0.5	0.5	mAdc
ON CHARACTERISTICS	(39)	R CURRENT IAN	15 COLLECTO	
DC Current Gain  (I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)  (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)  (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)  (I <sub>C</sub> = 0.4 Adc, V <sub>CE</sub> = 3.0 Vdc)	hFE 30ATJOVE	100 500 2000 200	5,000 20,000	38001
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 0.15 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 0.1 Adc)	VCE(sat)		4.0 2.8	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 0.15 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 0.1 Adc)	VBE(sat)		4.5 3.5	Vdc
Collector-Emitter Diode Voltage Drop (I <sub>EC</sub> = 15 Adc)	V <sub>F</sub>		4.5	Vdc
DYNAMIC CHARACTERISTICS	TRS.		III Emily	
Magnitude of Common-Emitter Small-Signal Short-Circuit Current Transfer Ratio (I <sub>C</sub> = 3.0 Adc, $V_{CE}$ = 3.0 Vdc, f = 1.0 MHz)	Ihfel	10	200	
SWITCHING CHARACTERISTICS RESISTIVE LOAD (Figure 2)				Linds
Delay Time (V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 10 Adc, I <sub>B1</sub> = 0.1 Adc,	td		0.15	μς
Rise Time t <sub>p</sub> = 300 µs, Duty Cycle ≤ 2.0%)	tr	ST THE LINE WIL	1.0	μs
Storage Time $(V_{CC} = 30 \text{ Vdc}, I_C = 10 \text{ Adc}, I_{B1} = I_{B2} = 0.1 \text{ Adc},$	ts		2.0	μς
Fall Time t <sub>p</sub> = 300 μs, Duty Cycle ≤ 2.0%)	tf	-	7.0	μs

\*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

### FIGURE 1 – RATED FORWARD BIASED SAFE-OPERATING AREA

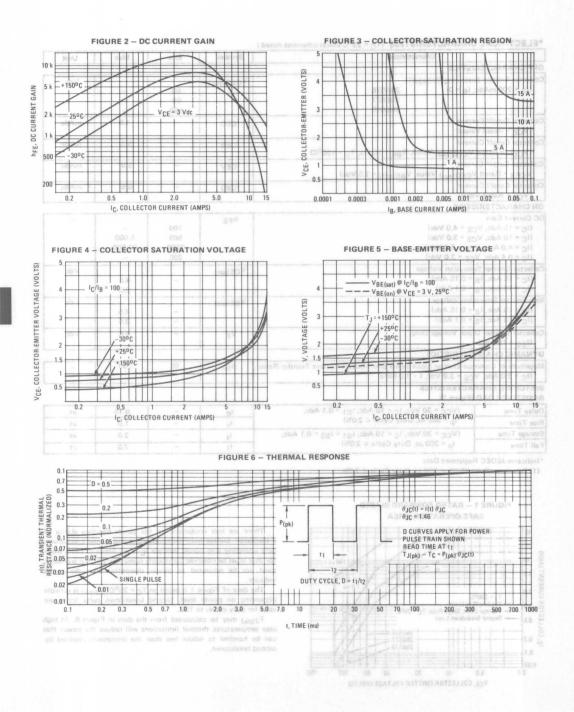


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_C = 25^0 C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10%.

 $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.







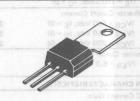
#### NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

. . . designed for horizontal drive applications, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage BVCEO = 250 Vdc (Min) @ IC = 1.0 mAdc - 2N6593
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 1.5 Vdc (Max) @ IC = 200 mAdc
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C

#### DUOWATT

**NPN SILICON** AMPLIFIER TRANSISTORS



#### MAXIMUM RATINGS

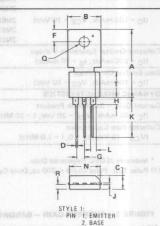
Rating	Symbol	2N6591	2N6592	2N6593	Unit
*Collector-Emitter Voltage	VCEO	150	200	250	Vdc
*Collector-Base Voltage	VCBO	150	200	250	Vdc
*Emitter-Base Voltage	VEBO	4 (1)	- 5.0 -		Vdc
*Collector Current - Continuous Peak (1)	1C	4	— 0.5 — — 1.0 —		Adc
*Base Current	1 <sub>B</sub>	-	—100 —	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	4	— 2.0 — — 16 —		Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	(3)	10 80	CHARA	Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	19941	-55 <sub>-</sub> to +15	0	°C
*Solder Temperature, 1/16" from Case for 10 Seconds			<u> 260 – </u>		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

\*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 1.0 ms, Duty Cycle ≤ 50%.



2. BASE 3. COLLECTOR 4. COLLECTOR

	MILETIN	urirus	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
Н	1.70	1.96	0.067	0.077	
J	0.48	0.66	0.019	0.026	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
0	3.56	3.81	0.140	0.150	
R	1,07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

**CASE 306-04** TO-202AC

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS	NPM SH JCON ANNUL AR					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	2N6591 2N6592 2N6593	SAOT	BVCEO	150 200 250	GH VOLTAG	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	2N6591 2N6592 2N6593	voltage linear	BVCBO 374	150	igned for horiz c, and high-volt	esb Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)			BVEBO	5.0	color the semantic	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 200 Vdc, I <sub>E</sub> = 0)	2N6591 2N6592 2N6593	593	Ing_lCBO <sub>in 0.1</sub> - epstlo ab Am 002	Saturation V	0.2 0.2 0.2	DAAµ SV Low C
Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)			OB31	- T @ noitsgiss	nt Pacif.0o – atts Free Air D	
ON CHARACTERISTICS(1)						

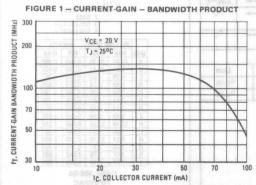
#### DC Current Gain hFE 2N6591 40 250 $(I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ 2N6592 30 250 2N6593 30 250 (I<sub>C</sub> = 100 mAdc, V<sub>CE</sub> = 10 Vdc) 2N6591 40 200 2N6592 40 200 2N6593 30 200 8.0 Collector-Emitter Saturation Voltage VCE(sat) Vdc (I<sub>C</sub> = 200 mAdc, I<sub>B</sub> = 20 mAdc) Base-Emitter On Voltage 1.0 Vdc (I<sub>C</sub> = 100 mAdc, V<sub>CE</sub> = 10 Vdc) DYNAMIC CHARACTERISTICS

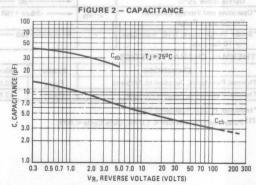
 
 DYNAMIC CHARACTERISTICS

 Current-Gain — Bandwidth Product (I<sub>C</sub> = 50 mAdc, V<sub>CE</sub> = 20 Vdc, f = 20 MHz)
 9 5 300 MHz

 Collector-Base Capacitance (V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f = 1.0 MHz)
 12 pF

#### TYPICAL CHARACTERISTICS

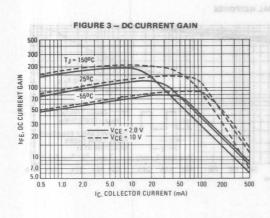


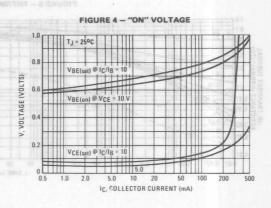


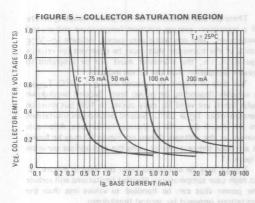
3

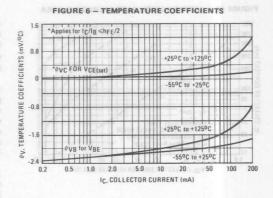
<sup>\*</sup> Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤2.0%.

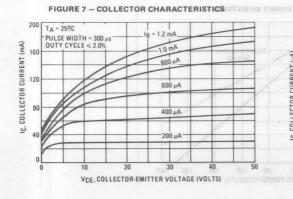
#### TYPICAL CHARACTERISTICS (Continued)

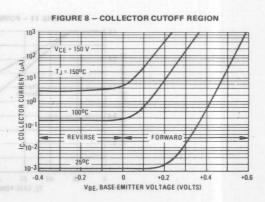












#### TYPICAL CHARACTERISTICS (Continued)

FIGURE 9 - THERMAL RESPONSE

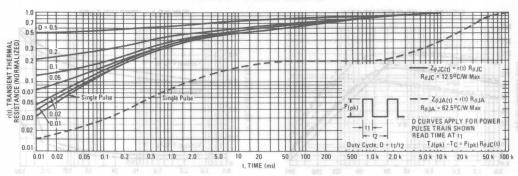
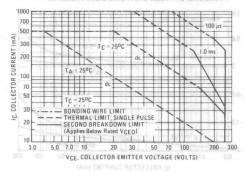


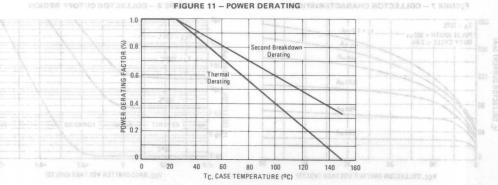
FIGURE 10 - ACTIVE REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCF limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 10 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on

TJ(pk) may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





#### PNP SILICON POWER TRANSISTOR

The 2N6594 is a general-purpose, EPI-BASE power transistor designed for low voltage amplifier and power switching applications. It is a complement to the NPN 2N6569.

- Safe Operating Area Full Power Rating to 40 V
- EPI-BASE Performance in Gain and Speed
- Lower Voltage, Economical Complement to the 2N3055



ELECTRICAL CHARACTERISTICS

100 W 2 4 40 VOLTS 30 4 4 VEDVI

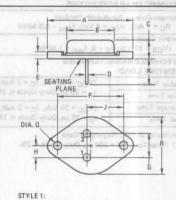


#### \*MAXIMUM RATINGS

INIAXIIVIONI RATTINGS			
Rating 8 1	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	40	Vdc
Collector-Base Voltage	VCBO	45	Vdc
mitter-Base Voltage	VEBO	5	Vdc
Collector Current — Continuous — Peak	¹c	12 24	Adc
Base Current — Continuous — Peak	IB	5 10	Adc
Emitter Current — Continuous — Peak	ΙE	17 34	Adc
otal Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	100 0.572	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200	°C
Temperature Range			

#### THERMAL CHARACTERISTICS

THE TIME OF A TANK OF THE TOTAL OF THE TANK OF THE TAN						
Characteristic	Symbol	Max	Unit			
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.75	°C/W			
Maximum Lead Temperature for Soldering Purposes: 1/16" from Case for 10 seconds	TLOR	265	°C			

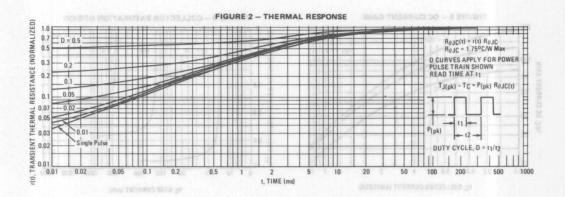


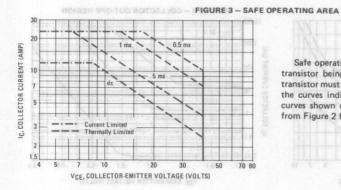
STYLE 1:
PIN 1. BASE
2. EMITTER
1. DIM "Q" IS DIA.

	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	_	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
1	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67	-	1.050

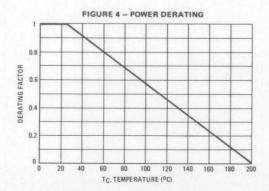
CASE 11-01 (TO-3) \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

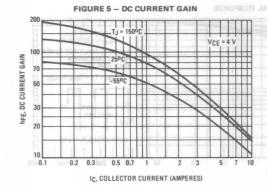


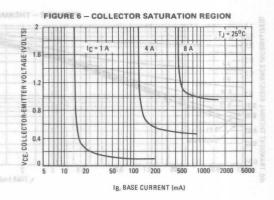




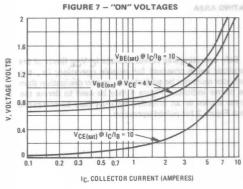
Safe operating area curves indicate  $I_{C}$ - $V_{CE}$  limits of the transistor being observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. Figure 4 may be used to derate the curves shown or an effective  $R_{\theta}$   $J_{C(t)}$  may be computed from Figure 2 for pulsed operation.

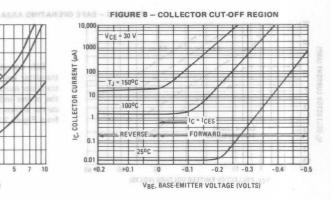


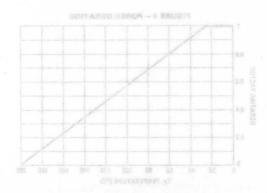












#### PLASTIC MEDIUM-POWER SILICON TRANSISTORS

.. designed for general-purpose amplifier and low speed switching applications.

- High DC Current Gain hFE = 3500 (Typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 200 mAdc

VCEO(sus) = 40 Vdc (Min) — 2N6666

- = 60 Vdc (Min) 2N6667
- = 80 Vdc (Min) 2N6668
- Low Collector-Emitter Saturation Voltage VCE(sat) = 2.0 Vdc (Max) @ IC = 3.0 Adc - 2N6666

VCE(sat) = 2.0 Vdc (Max) @ IC = 5.0 Adc — 2N6667, 2N6668

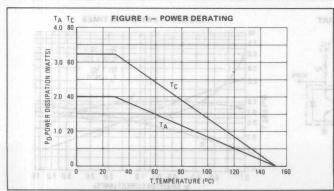
- Monolithic Construction with Built-In Base-Emitter **Shunt Resistors**
- TO-220AB Compact Package
- Complementary to 2N6386, 2N6387, 2N6388

#### \*MAXIMUM RATINGS

WAXIIII OW WATIII GO						
Rating	Symbol	2N6666	2N6667	2N6668	Unit	
Collector-Emitter Voltage	VCEO	40	60	80	Vdc	
Collector-Base Voltage	VCB	40	60	80	Vdc	
Emitter-Base Voltage	VEB	4	— 5.0 —	>	Vdc	
Collector Current — Continuous Peak	IC	8.0 15	10 15	10 15	Adc	
Base Current 8.5	IB	4	<u> 250</u>	-	mAdc	
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4	— 65 — — 0.52 —	- gaange	Watts W/°C	
Total Device Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	<b>4</b>	2.0 0.016	<b>→</b>	Watts W/°C	
Operating and Storage Junction, Temperature Range	TJ, T <sub>stg</sub>	4	-65 to +150	)	°C	

#### THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.92	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta}$ JA	62.5	°C/W



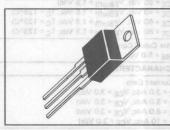
\*Indicates JEDEC Registered Data

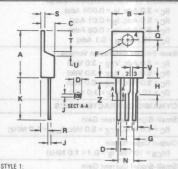
#### DARLINGTON **8 AND 10 AMPERE**

"ELECTRICAL CHARACTERISTICS (To = 25

#### PNP SILICON **POWER TRANSISTORS**

40-60-80 VOLTS 65 WATTS





STYLE 1: PIN 1. BASE IN 1. BASE NOTES:
2. COLLECTOR 1. DIMENSION H APPLIES TO ALL LEADS 3. EMITTER 2. DIMENSION L APPLIES TO LEADS 1

	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
E	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
2	-	2.03	-	0.080

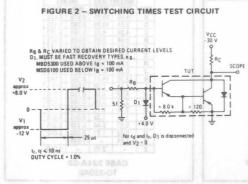
CASE 221A-02 TO-220AB

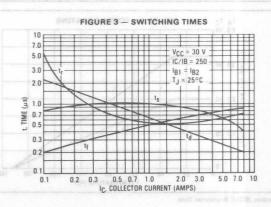


#### \*ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit	
OFF CHARACTERISTICS							
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N6666 2N6667 2N6668	STORS		VCEO(sus)	40 60 80	MEDIUM for venerals	DLASTIC designed
Collector Cutoff Current (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 80 Vdc, I <sub>B</sub> = 0)	2N6666 2N6667 2N6668			ICEO	1C = 6:0 AI	1.0 1.0 1.0	an mAdd ggs D OG rigit G S = gqr
Collector Cutoff Current (VCE = 40 Vdc, VEB(off) = 1.5 Vdc) (VCE = 60 Vdc, VEB(off) = 1.5 Vdc) (VCE = 80 Vdc, VEB(off) = 1.5 Vdc) (VCE = 40 Vdc, VEB(off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (VCE = 60 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C) (VCE = 80 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	2N6666 2N6667 2N6668 2N6666 2N6667 2N6668	OK SWARA	2Ness	Sacok — sgarloV	(Min) — 2 (Min) — 2 (Min) — 2 (Win) — 2 Serotesion (Max) @ I Max) @ I	300 300 300 3.0 3.0 3.0	μAdc mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			1070	EBO ALT	ue name no	5.0	mAdc
ON CHARACTERISTICS (1)					mandan	Common S	ange of a
DC Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N6666	2N6668 2N6668	17887	assore Tee	1000 1000 100 100	20000	0 Complem KINUM RAT
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.006 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.01 Adc) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 0.08 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 0.1 Adc)	2N6666 2N6667, 2N6666	2N6668 2N6668	01	VCE(sat)	Vc80 Vc8 -Vs6	2.0 2.0 3.0 3.0	oV nVdc 3-ros stoV sas 3-ros gatieV and5-ro - tnenu X to
Base-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)	2N6666	2N6668 2N6668	80 — 88 — 82 —	V <sub>BE(sat)</sub>	g - g9_ g9	2.8 2.8 4.5 4.5	Vdc incrept and a Drasipar ate a rove 25%
DYNAMIC CHARACTERISTICS	SHEW	45	200	1.0	di bis	ez - Vi el un	DBWC e Urssipan
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	200	-0]	08100	hfe	20	neitanut sp	ting and Store
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	h-man-d			C <sub>ob</sub>	108	200	IAH PELAMI
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 kHz)	Unit W/\D°	9.2		h <sub>fe</sub>	1000	et neitanut	entoento
*Indicates JEDEC Registered Data	WAS	8.1	10	ALBH	t/neidm/	Junction to A	ensistence.

(1) Pulse Test: Pulse Width  $\leqslant$  300  $\mu$ s, Duty Cycle  $\leqslant$  2.0%.







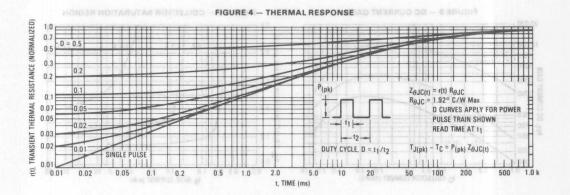
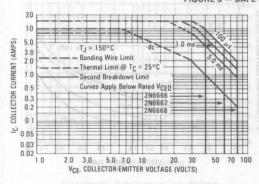


FIGURE 5 - SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown, Safe operating area curves indicate  $I_{\rm C}-V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}$  = 150°C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} <$  150°C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 6 - SMALL-SIGNAL CURRENT GAIN

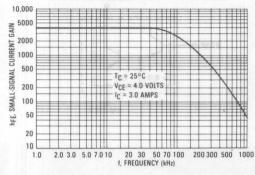
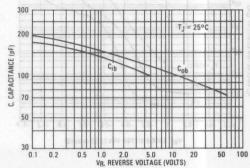
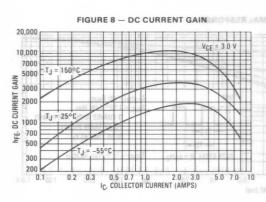
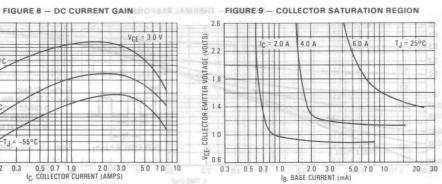


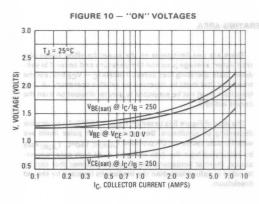
FIGURE 7 - CAPACITANCE

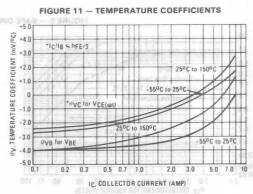


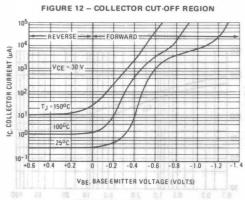












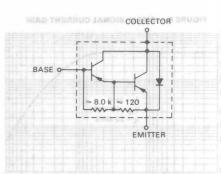


FIGURE 13 - DARLINGTON SCHEMATIC

The 2N6676, 2N6677 and 2N6678 transistors are designed for high voltage switching applications such as:

- Off-Line Power Supplies
- Converter Circuits
- Pulse Width Modulated Regulators

Specification Features —

High Voltage Capability

Fast Switching Speeds

Low Saturation Voltages

High SOA Ratings

#### MAXIMUM RATINGS

Rating	Symbol	2N6676	2N6677	2N6678	Unit
Collector Emitter Voltage	VCEV	450	550	650	Vdc
Collector Emitter Voltage	VCEX	350	400	450	Vdc
Collector Emitter Voltage	VCEO	300	350	400	Vdc
Emitter Base Voltage	VEBO		8		Vdc
Collector Current - cont - peak	I <sub>C</sub>		15 20		Adc
Base Current - cont	I <sub>B</sub>		5		Adc
Power Dissipation T <sub>C</sub> = 25°C Derate above 25°C	PT	8 <sup>†</sup>	175 ° 25 ° 5T 1		Watts W/°C
Operating and Storage Junction	T <sub>J</sub> ;	b <sup>†</sup>	-65 to 200		°C
Thermal Resistance Junction to Case	R <sub>θ</sub> JC	1.0			°C/W
Maximum Lead Temperature At Distance > 1/16 in. (1.58 mm) from seating plane for 10 s max.		2'	235 5°85 = 5T 5°801 = 5T		°C

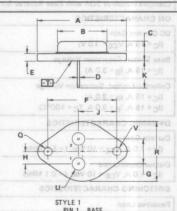
# ELECTRICAL CHARACTERISTICS (To a satisfied a satisfied

## NPN SILICON AND HOP POWER TRANSISTORS

300, 350, 400 VOLTS 175 WATTS

(VEB = 8.0 Vdc. (c = 0)





PIN 1. BASE
2. EMITTER
CASE COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	D 17	39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	1.40	1.78	0.055	0.070
F	30.15 BSC		1.187 BSC	
G	10.92	BSC	0.430 BSC	
Н	5.46	BSC	0.215 BSC	
J	16.89 BSC		0.665	BSC
K	11.18	12.19	0.440	0.480
0	3.81	4.19	0.150	0.165
R	Simil.	26.67	-	1.050
U	4.83	5.33	0.190	0.210
٧	3.81	4.19	0.150	0.165

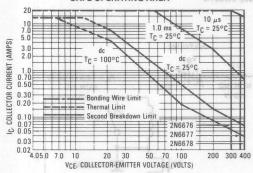
**CASE 1-05** 

3

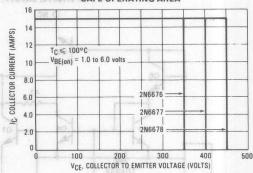
**CARE 1-06** 

	Characteristic				Symbol	Min	Max	Unit
OFF CHARACTER	ISTICS 4/4							
(VCE = Rated VCE	rrent :v, V <sub>BE(off)</sub> = -1.5 Vdc) :v, V <sub>BE(off)</sub> , TC = 100°C)			SISTOR	ICEV	UCO <u>N</u> POV	0.1	mA
Emitter Cutoff Curr (VEB = 8.0 Vdc, Id			esigned for	b era aroto	I <sub>EBO</sub>	1077 and 2N	NESOS, 210	
Collector-Emitter S (I <sub>C</sub> = 200 mA, I <sub>B</sub>	The second secon	2N6676 2N6677 2N6678		VCEO(sus)	250	ine P <del>o</del> ver S erter <u>C</u> ircult		
Collector-Emitter S (IC = 15 A, Volam		2N6676 2N6677 2N6678		VCEX(sus)	350 400 450	lication Fest h Voluge Ca Switching		
SECOND BREAK	DOWN					Voltages	noirement on	WO.
Second Breakdown Collector Current with Base Forward Biased				IS/b	20	See Figure 1		
Clamped Inductive SOA with Base Reverse Biased				RBSOA		See Figure 2		
ON CHARACTER		1				1		
DC Current Gain (IC = 15 A, VCE =	-1-		-		hFE	8.0	_	-
Base Emitter Satur (I <sub>C</sub> = 15 A, I <sub>B</sub> = 3	mitter Saturation Voltage 15 A, I <sub>B</sub> = 3.0 A)			V <sub>BE(sat)</sub>		1.5	Vdc	
Collector-Emitter, S (I <sub>C</sub> = 15 A, I <sub>B</sub> = 3 (I <sub>C</sub> = 15 A, I <sub>B</sub> = 3	0 A)				VCE(sat)	_	1.5	Vdc
DYNAMIC CHAR	ACTERISTICS	stati	294673	ствент 1	2149879	Sureched	The second second second	948
Current Gain (IC = 1.0 A, VCE =	: 10 Vdc, f = 5.0 MHz)	Vide	089	caa	olhfel	3.0	10	
Output Capacitance (I <sub>C</sub> = 1.0 A, V <sub>CB</sub> =	e = 10 Vdc, f = 0.1 MHz)	obV	400	380	C <sub>ob</sub>	150	500	pF
SWITCHING CHA	RACTERISTICS	Vdc		В		osay	9981	oV ens@ rez
Resistive Load	· 1 33972	Ado		16		ol le	(ffice - )	ettor Curren
Delay Time	2 EM1			95	t <sub>d</sub>	MOS.	0.1	μS
Rise Time	V <sub>CC</sub> = 200 V, I <sub>C</sub> = 15 A,	obp.			tr	187	0.6	- mmu2)
Storage Time	I <sub>B1</sub> = I <sub>B2</sub> = 3.0 A, t <sub>D</sub> = 20 μs	, essevy	T <sub>C</sub> = 2	5°C	ts	79 _	2.5	dagreziú se
Fall Time	Duty Cycle ≤ 2.0%	Do W		1	tf	-	0.5	evona etsti
Delay Time	$V_{BB} \simeq 6.0 \text{ V}, R_L \simeq 13.5 \Omega$	2		-65 to 200	td	47 -	0.4	ber getter
Rise Time	(See Figure 3)				tr	Gay -	1.0	notion
Storage Time		W-100	T <sub>C</sub> = 10		ts		4.0	
Fall Time	318-21.00	N. P.	1	1.0	tf	168M -	1.0	met Basista
Inductive Load	A DMR (8.6)   D		1	2000				10000
Cross Over Time	L = 50 μH	1 10	T <sub>C</sub> = 2	5°C	t <sub>c</sub>		0.5	μs
881.0 981.0	V <sub>clamp</sub> = Rated V <sub>CEX</sub> (See Figure 3)		T <sub>C</sub> = 10				0.8	State 10 a

FIGURE 1 — MAXIMUM RATED FORWARD BIAS 1024 M AND FIGURE 2 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



STORMS DIAM STORMS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

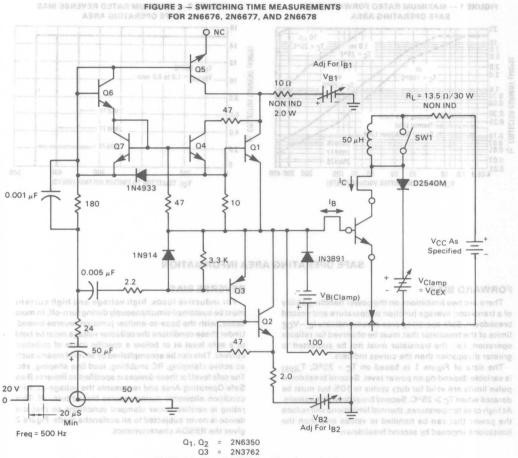
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 2 gives the RBSOA characteristics.



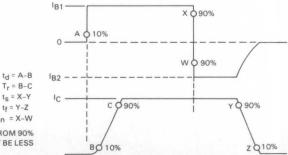


Q4, Q5, Q6, Q7 = CA3725 Quad Transistor Array

ts = X-Y  $t_f = Y - Z$ 

NOTE: Battery symbols VCC, VB1, VB2, VB(clamp) indicate rigorously filtered voltage sources at the circuit terminals to accommodate the fast rise and fall times and high currents present in the circuit.

NOTE: SW1 closed for t<sub>r</sub>, t<sub>s</sub>, t<sub>f</sub>. SW1 open for t<sub>C</sub>



t<sub>transistion</sub> = X-W NOTE: TRANSITION TIME FROM 90% IB1 to 90% IB2 MUST BE LESS THAN 0.5 μs



### Designer's Data Sheet

#### **SWITCHMODE III SERIES** NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

Typical Applications:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times 50 ns Inductive Fall Time - 75°C (Typ) 70 ns Inductive Crossover Time - 75°C (Typ) 500 ns Inductive Storage Time - 75°C (Typ)
- Operating Temperature Range -65 to +150°C
- 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents

#### MAXIMUM RATINGS

Rating	Symbol	2N6833	2N6834	Unit
Collector-Emitter Voltage*	VCEO(sus)	4	50	Vdc
Collector-Emitter Voltage*	VCEV	8	50	Vdc
Emitter Base Voltage*	VEB	6.0		Vdc
Collector Current — Continuous* — Peak (1)	I <sub>C</sub>	5.0 10		Adc
Base Current — Continuous* — Peak (1)	I <sub>B</sub>	4.0 8.0		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C* @ T <sub>C</sub> = 100°C* Derate above 25°C*	PD	80 32 0.64	125 71.5 0.714	Watts W/°C
Operating and Storage Junction Temperature Range*	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	-65 to +200	°C

#### THERMAL CHARACTERISTICS

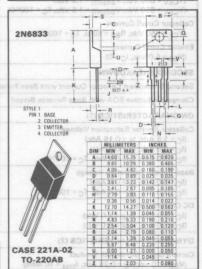
Characteristic	Symbol	2N6833	2N6834	Unit
Thermal Resistance, Junction to Case*	$R_{\theta}JC$	1.56	1.40	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds*	TL	275		°C

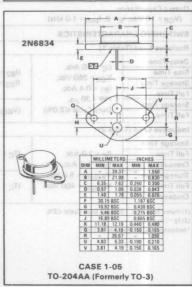
(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%. \*Indicate JEDEC Registered Data

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

### THEOTRICAL STARMA O. 5 ISTICS IT **NPN SILICON POWER TRANSISTORS** 450 VOLTS 80 and 125 WATTS



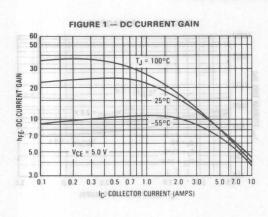


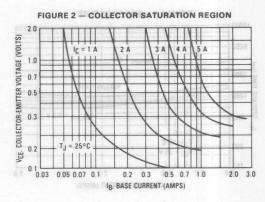
286834

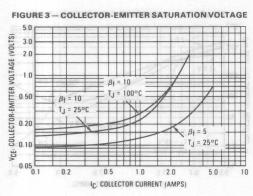


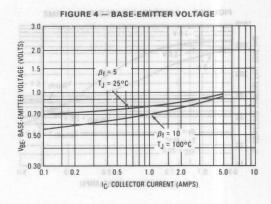
	Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTERIS	STICS			internet	u no ne	PATE 1 A 100		
Collector-Emitter Sustaining Voltage (Table 2) (I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)		VCEO(sus)	450*	PEOWER 1	OOITS N	Vdc Vdc		
(V <sub>CEV</sub> = 850 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc)		ICEV	ov-rigiri v Vice <del>s i</del> elit d s <del>wi</del> tche	Jasigned for ive c <del>ir</del> cuits v line <del>c</del> oerate	0.25*00	ns mAde il I	Q .	
Collector Cutoff Curr			CER	-	-	2.5	mAdc	Y
Emitter Cutoff Currer (V <sub>EB</sub> = 6.0 Vdc, I <sub>C</sub> :	The second second		IEBO	-	-	1.0*	mAdc	
SECOND BREAKD	OWN	0			8191			
Second Breakdown (	Collector Current with	Base Forward Biased	Is/b		See Figures	15* and 16*	ino 3 totoM	
Clamped Inductive S	OA with Base Reverse	Biased	RBSOA	0		igure 17	Derleggen	-
- + + + + + + + + + + + + + + + + + + +	R-m	SIME SHO				semil No	<del>- Fast Turn C</del>	10
ON CHARACTERIS	Township 100,000 to		1 4		ime - 75°C	_		1
Collector-Emitter Sat (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 0 (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0	0.15 Adc)		VCE(sat)	78°C (T) 78 <del>°C</del> (T)	cover Timo rego <del>-T</del> imo Range86	1.0	Vdc	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0	).4 Adc, T <sub>C</sub> = 100°C)			3/3/4/17 3/	Wal- ognion	2.5*	Shirta Lordon	
Base-Emitter Saturat (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0	).4 Adc)		V <sub>BE(sat)</sub>	ve Loads	with Inductive I.	1.5*	Vdc	
DC Current Gain	0.4 Adc, T <sub>C</sub> = 100°C) = 5.0 Vdc)		hFE	7.5*	_	1.5	<del>sica quae i.</del> Legazige i.	
(IC = 5.0 Adc, VCE	= 5.0 Vdc)			5.0				
DYNAMIC CHARAC	CTERISTICS (2)	V				801	ATTAIN BOUND	IXAI
Current Gain - Bandy (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> =	vidth Product 0.25 Adc, f <sub>test</sub> = 10 N	AHz)	f <sub>T</sub>	15*	DV -	75*	MHz	mello
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> =	0, f <sub>test</sub> = 1.0 kHz)	Vds	Cob	20*	-	200*	ogniov each	olieuri mitter
SWITCHING CHAR	ACTERISTICS	260	5.0					73effe
Resistive Load (Tabl	e 1)	M.C.	0.1	Ind		(1) 889.	1	
Delay Time	1 1	Ado	t <sub>d</sub>	_ 8	30	100*	ns	D Bidn
Rise Time	(I <sub>C</sub> = 3.0 Adc,	(I <sub>B2</sub> = 0.8 Adc,	tr	_148	100	300*	- Feat	
Storage Time	V <sub>CC</sub> = 250 Vdc, I <sub>R1</sub> = 0.4 Adc,	R <sub>B2</sub> = 8.0 Ω)	ts	- 09	1000	3000*	description to see	M listo
Fall Time	PW = 30 μs,	1 2000	tf		60	300*	OFFIC evolve at	-
Storage Time	Duty Cycle ≤2.0%)	(VBE(off) = 5.0 Vdc)	t <sub>S</sub>		400		persid the pri	-
Fall Time	-G9-1	0	tf	#181 ·	130	nortanut e	State of the state of the	meT
nductive Load (Tabl	e 2)	4						
Storage Time			tsv		500	1600*	ns	Ran
Fall Time	(I <sub>C</sub> = 3.0 Adc,	(T <sub>C</sub> = 100°C)	tfi	1 Autor	100	200*	Charse	
Crossover Time	I <sub>B1</sub> = 0.4 Adc, V <sub>BE(off)</sub> = 5.0 Vdc,	B/ Who 0	t <sub>c</sub>	791.0	120	250*	# Resistance	man
Storage Time		(T <sub>C</sub> = 150°C)	tsv	- 7	600	2 salanicans	(mail beed form)	miss
Fall Time	VCE(pk) = 400 Vdc)		tfi	_	120	End Ford) o	ones: 1/8" from	
Crossover Time  1) Pulse Test: PW - 300 2) fT =   hfe  ftest			t <sub>C</sub>		160	STO JUNE DUTE SEL DIRECTO	estrigeR 330\$L	Pubsa dique
Indicates JEDEC Regist	ered Limit		ansitibn	Case" Ca	2010W 101 C	tsiS a'temples		

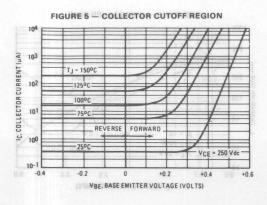
#### TYPICAL STATIC CHARACTERISTICS

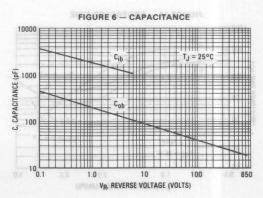




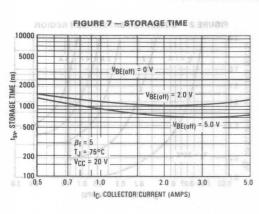


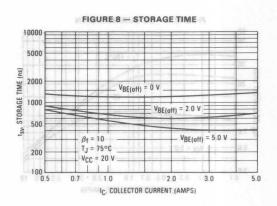


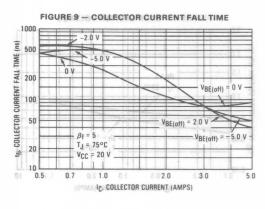


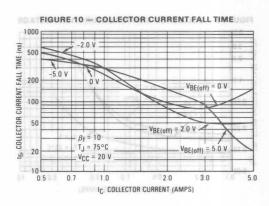


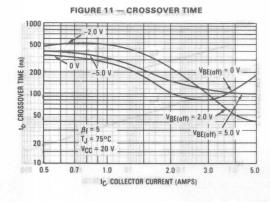
#### TYPICAL DYNAMIC CHARACTERISTICS

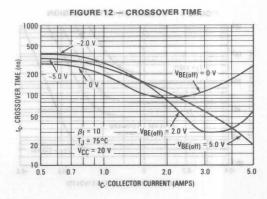






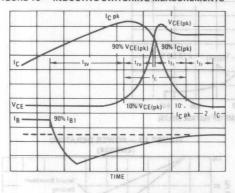




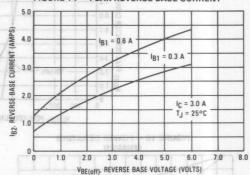








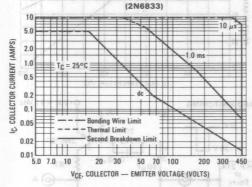
#### FIGURE 14 — PEAK REVERSE BASE CURRENT



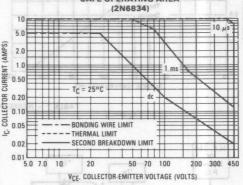
#### **GUARANTEED SAFE OPERATING AREA LIMITS**

PIGURE 17 -- MAXIMUM REVERRE BIAS

FIGURE 15 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 16 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 15 and 16 are based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25$ °C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 15 and 16 may be found at any case temperature by using the appropriate curve on Figures 18 or 19.

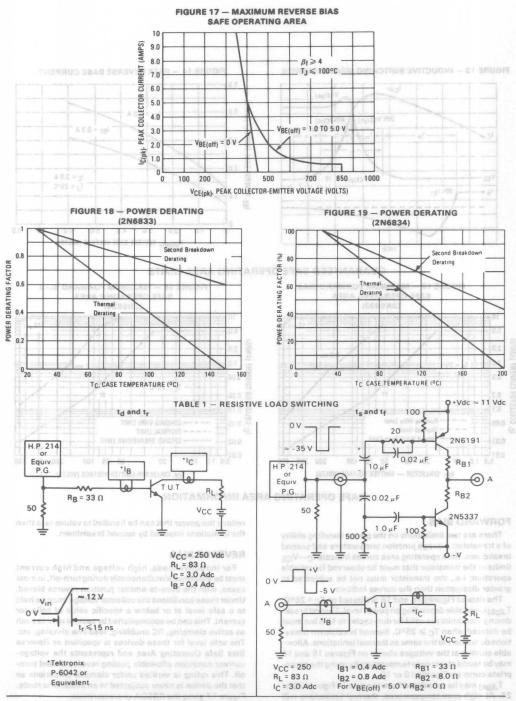
T<sub>J(pk)</sub> may be calculated from the data in Figures 20 or 21. At high case temperatures, thermal limitations will

reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable putting reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

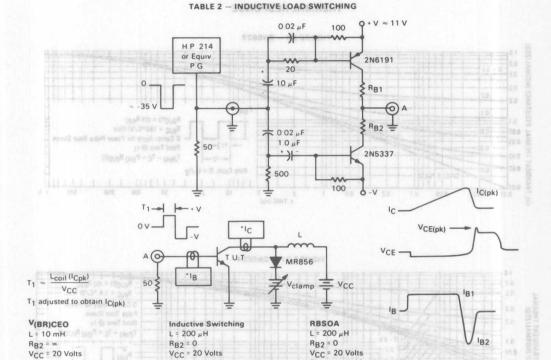




\*Tektronix P-6042 or

Equivalent





#### TYPICAL INDUCTIVE SWITCHING WAVEFORMS

RB1 selected for desired IB1

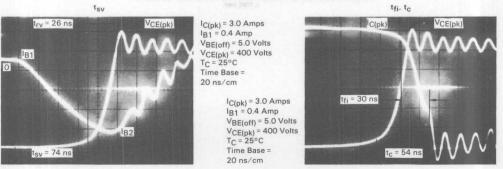
Note: Adjust -V to obtain desired VBE(off) at Point A.

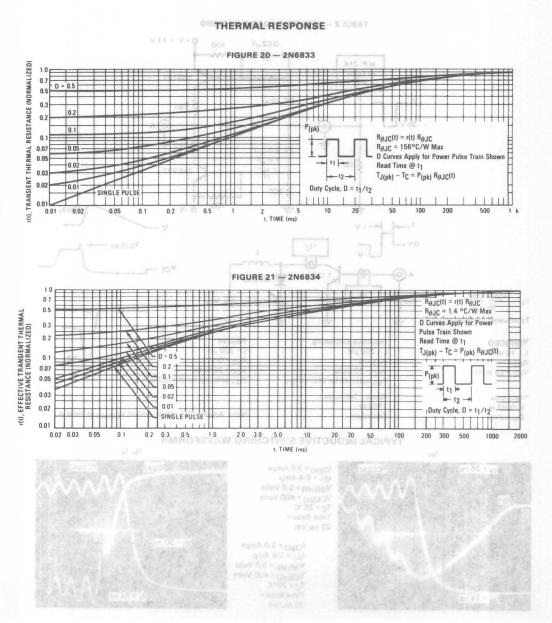
RB1 selected for desired IB1

Scope - Tektronix

7403 or

Equivalent







#### Designer's Data Sheet

### SWITCHMODE III SERIES ULTRA-FAST NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

- Switching Regulators
- Inverters
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
   90 ns Inductive Fall Time 75°C (Typ)
   90 ns Inductive Crossover Time 75°C (Typ)
   450 ns Inductive Storage Time 75°C (Typ)
- Operating Temperature Range –65 to +200°C
- 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents

#### \*MAXIMUM RATINGS

Rating	Symbol	Max	Unit	
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	450	Vdc Vdc	
Collector-Emitter Voltage	VCEV	850		
Emitter Base Voltage	V <sub>EB</sub>	6.0	Vdc	
Collector Current — Continuous — Peak (1)	Ic IcM	8.0 16	Adc	
Base Current — Continuous — Peak (1)	I <sub>B</sub>	6.0	Adc	
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C	PD	150 85.5	Watts	
Derate above 25°C		0.86	W/°C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C	

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit °C/W	
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.17		
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5.0 Seconds	TL	275	°C	

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle  $\leq$  10%.

\*Indicate JEDEC Registered Data

#### 8 AMPERE

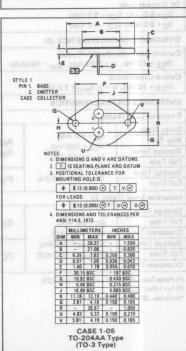
## NPN SILICON POWER TRANSISTORS

450 VOLTS (1000) notcello

### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

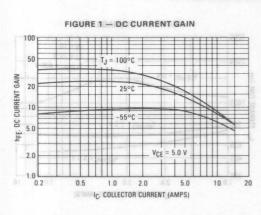


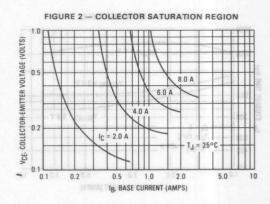


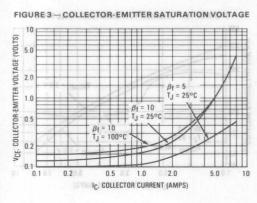
-24	Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTER	RISTICS (1)	11						
Collector-Emitter Sustaining Voltage (Table 2) (I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)			VCEO(sus)	450*	GONTHOT	MS-	Vdc	
Collector Cutoff Current (VCEV = 850 Vdc, VBE(off) = 1.5 Vdc) (VCEV = 850 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 100°C)		ICEV	r-ri <u>pid</u> 10	l beng <u>in</u> eb s	0.25* 1.5*	mAdc		
Collector Cutoff Cu (V <sub>CE</sub> = 850 Vdc,	rrent RBE(off) = 50 Ω, T <sub>C</sub> = 100	PC)	ICER	tod averted	eleana evisa elega-anti ro	2.5	mAdc	
Emitter Cutoff Curr (V <sub>EB</sub> = 6.0 Vdc, I <sub>0</sub>			I <sub>EBO</sub>	-		*0.1	mAdc	
SECOND BREAK	DOWN Angland off	11	3				atabayni 6	
80 ANTO 10 STREET	Collector Current with E	Base Forward Biased	Is/b		See Figure 15		030210711	
- Etaly Dated And	SOA with Base Reverse	- 1 0 Hd	RBSOA		See Figure 16			
A C 10 C 1 C 1 C 1 C 1 C 1 C 1 C 1 C 1 C	win was a called herood	Diasca	MOOOA		occ riguic re	Direction :	Defloction	
ON CHARACTERISTICS (1)  Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.40 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.66 Adc)		V <sub>CE(sat)</sub>	0 - 75°C ( - 75°C (	II Time — 75 ossover Time	2.5*	Vdc		
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub>	= 0.66 Adc, T <sub>C</sub> = 100°C)	11	= (dA	_	_	3.0*		
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.66 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.66 Adc, T <sub>C</sub> = 100°C)			VBE(sat)	5 to +200	ire Ranga - Specified for	1.5*	Vdc O	
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 5.0 Vdc)			hFE	7.5* 4.0*	vith Indiactive s	ng Times v	Saturat Saturat	
DYNAMIC CHAR	ACTERISTICS (2)							
Current Gain - Bandwidth Product (V <sub>CE</sub> = 10 Vdc, I <sub>C</sub> = 0.25 Adc, f <sub>test</sub> = 10 MHz)		fT	10*	_	75*	MHz		
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)			Cob	50*	_	350*	pF	
SWITCHING CHA	RACTERISTICS	969	Oil (aue)	1907		0061	oV settim3-set	
Resistive Load (Ta	ble 1)	Vde	088 VS			egati	tor-Emitter Ve	
Delay Time	A 9 11	Vete	da ta as	v _	20	50*	ns 9 %	
Rise Time	(I <sub>C</sub> = 5.0 Adc,	(I <sub>B2</sub> = 1.3 Adc,	t <sub>r</sub>	-	85	250*	2019076 7 107	
Storage Time	V <sub>CC</sub> = 250 Vdc,	$R_{B2} = 4.0 \Omega$	t <sub>s</sub>	N -	1000	2500*	_	
Fall Time	I <sub>B1</sub> = 0.66 Adc,		tf	-	70	250*	Surrent — Co	
Storage Time	PW = 30 μs, Duty Cycle ≤2.0%)	(Vps, 10 - 5 0 Vd-)	ts	-	500	-1714	Per - Per	
Fall Time	Duty Cycle <2.0%)	(VBE(off) = 5.0 Vdc)	tf	0 -	100	a wit ills only	eniesiCissues	
Inductive Load (Ta	ble 2)	1 1000	3.68		0100	= 37 G		
Storage Time	WE LOT THE ZULLOVER D. A.	20/4/9	t <sub>sv</sub>	_	700	1800*	ns	
Fall Time	(I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 0.66 Adc, VBE(off) = 5.0 Vdc, VCE(pk) = 400 Vdc)	(T <sub>C</sub> = 100°C)		JT -	80	200*	ting and Store	
Crossover Time			t <sub>c</sub>	-	150	250*	perature Ren	
Storage Time		(T <sub>C</sub> = 150°C)	t <sub>sv</sub>	_	800	mant va a	AHDJAMB	
Fall Time			tfi	-	80	_	AND THIS	
Crossover Time		zinU	tc Kid	mis _	200	SERVEDUSIN	RO.	
(2) f <sub>T</sub> =   she   f <sub>test</sub>	00 μs, Duty Cycle ≤2%.	W/38	275	16 P			at Ivesigrande, iten Laad Tem ropes: 1/8" fro	

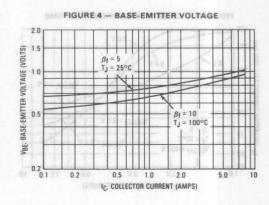
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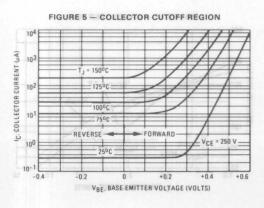
#### TYPICAL STATIC CHARACTERISTICS

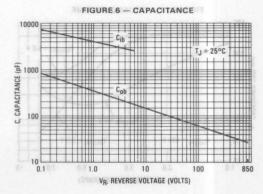




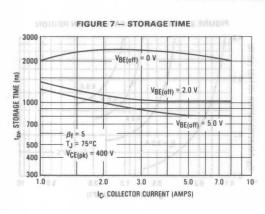


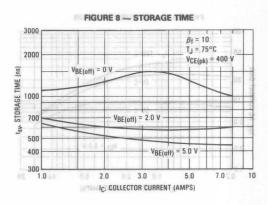


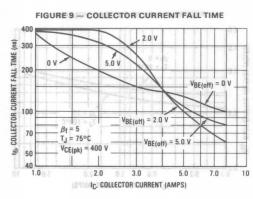


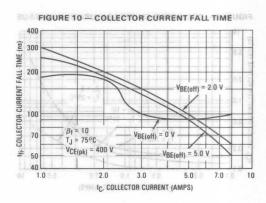


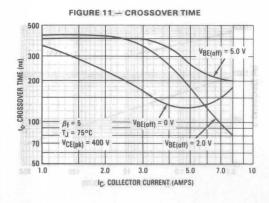
#### TYPICAL DYNAMIC CHARACTERISTICS

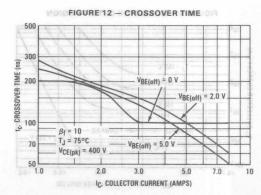


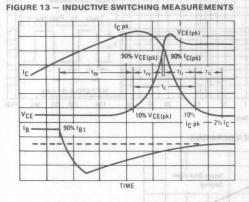


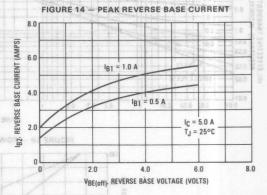




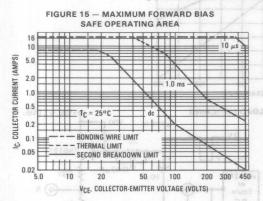


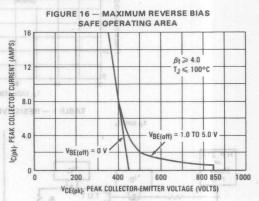






### **GUARANTEED SAFE OPERATING AREA LIMITS**





#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 15 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

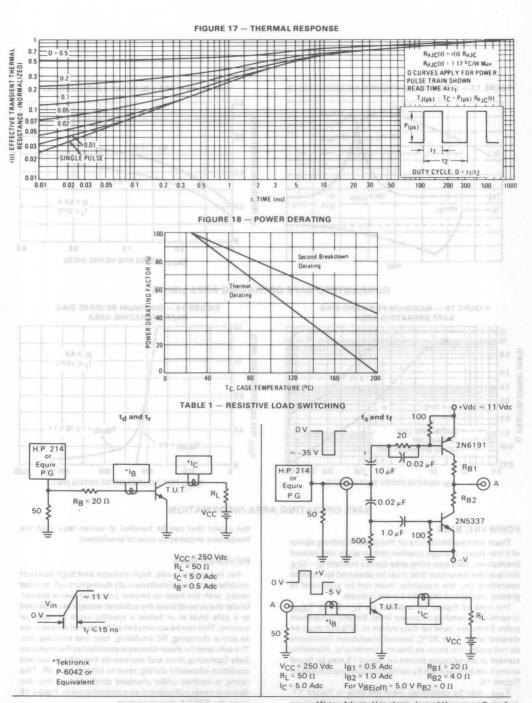
 $T_{J(pk)}$  may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will reduce

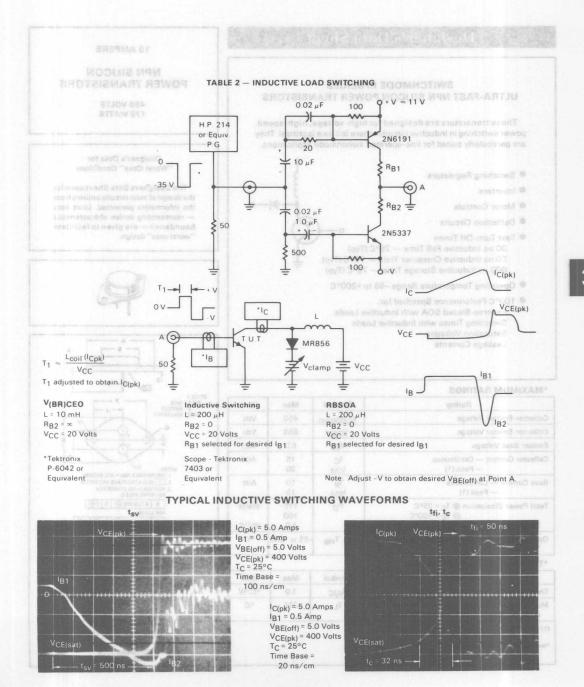
the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.







3-317



## Designer's Data Sheet

#### SWITCHMODE III SERIES GAGLEVITOUGH - S S ULTRA-FAST NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

- Switching Regulators
- Inverters
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
   30 ns Inductive Fall Time 75°C (Typ)
   50 ns Inductive Crossover Time 75°C (Typ)
   600 ns Inductive Storage Time 75°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for:
   Reverse-Biased SOA with Inductive Loads
   Switching Times with Inductive Loads
   Saturation Voltages
   Leakage Currents



Rating	Symbol	Max	Unit
Collector-Emitter Voltage	VCEO(sus)	450	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage rgl barisab tol be	VEB	6.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	15 20	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	10 15	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	175 100 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>Stg</sub>	-65 to +200	O°C al

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5.0 Seconds	TLagenA	275	°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

\*Indicate JEDEC Registered Data

#### 15 AMPERE

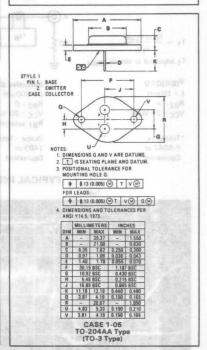
## NPN SILICON POWER TRANSISTORS

450 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

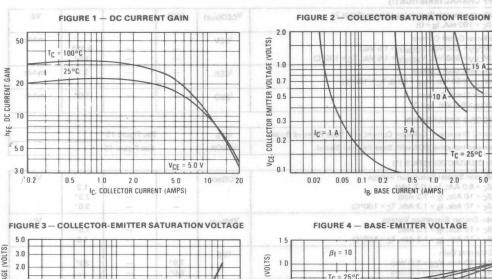
The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

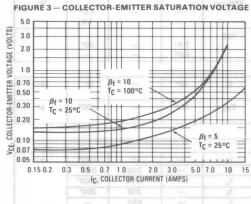


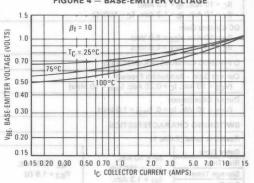


	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTE	RISTICS (1)						
	Sustaining Voltage (Table	2) 38437	VCEO(sus)	450*	DC CURRE	- r a <del>n</del> upr	Vdc
	urrent c, VBE(off) = 1.5 Vdc) c, VBE(off) = 1.5 Vdc, T <sub>C</sub> =	: 100°C)	ICEV		=	0.25* 1.5*	mAdc
Collector Cutoff Cu	The state of the s	HEET E	ICER			2.5	mAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0)		8.0 \$	IEBO	衎		1.0*	mAdc
SECOND BREAK	DOWN	V 20 2					1 0
Second Breakdown	n Collector Current with	Base Forward Biased	Is/b		See Figure 15		-
Clamped Inductive	SOA with Base Reverse	Biased	RBSOA		See Figure 10	6	
ON CHARACTER		1 8	1/		3.0		
		111111111	I Van	n.e = 93V			1/4-
(IC = 5.0 Adc, IB	collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.7 Adc)		VCE(sat)	5.8 T (A)(FS)	2.0 LLECTOR CLIBRES	1.2	Vdc
(Ic = 10 Adc, Ig =	= 1.3 Adc) = 1.3 Adc, T <sub>C</sub> = 100°C)			_		2.5* 3.0*	
Base-Emitter Satu	ration Voltage	PIGURE	VBE(sat)	OITABUT	EMITTER S.	1.5*	Vdc
	= 1.3 Adc, T <sub>C</sub> = 100°C)					1.5	
DC Current Gain (I <sub>C</sub> = 10 Adc, V <sub>C</sub>		8 1.0	hFE	7.5*		30*	- 3
(I <sub>C</sub> = 15 Adc, V <sub>C</sub>	E = 5.0 Vdc)			5.0*			
DYNAMIC CHAR	ACTERISTICS (2)	010 0					
Current Gain - Bar (VCE = 10 Vdc, I	ndwidth Product C = 0.25 Adc, f <sub>test</sub> = 10 N	MHz)	fT	10*	0001-	75*	MHz
Output Capacitano (V <sub>CB</sub> = 10 Vdc, I	ce E = 0, f <sub>test</sub> = 1.0 kHz)	90 0 S	C <sub>ob</sub>	50*	41	400*	pF 1
SWITCHING CHA	ARACTERISTICS						
Resistive Load (Ta	able 1)	\$ 0.20	D 25°C	111			
Delay Time		810	td		20	100*	ns
Rise Time	(I <sub>C</sub> = 10 Adc, V <sub>CC</sub> = 250 Vdc,	(IB2 = 2.6 Adc,	er tr av	0.0 - 0.0	200	500*	
Storage Time	I <sub>B1</sub> = 1.3 Adc,	$R_{B2} = 1.6 \Omega$ )	ts	(29MA)	1200	3000*	
Fall Time	PW = 30 µs,		tf		200	350*	
Storage Time Fall Time	Duty Cycle ≤2.0%)	(VBE(off) = 5.0 Vdc)	t <sub>S</sub>	18 44071	650	0-2980	
Inductive Load (Ta	able 2)	noint	4		30		
Storage Time		0003	I Tentral		800	1800*	ns
Fall Time	(Ic = 10 Adc,	(Tc = 100°C)	t <sub>SV</sub>	7	50	200*	
Crossover Time	I <sub>B1</sub> = 1.3 Adc,	2000	tc	747	90	250*	
Storage Time	VBE(off) = 5.0 Vdc,	A 1009 lecture 1001 A	tsv	-	1050	3-0617	
Fall Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>C</sub> = 150°C)	tfi	19 - N.	70	J'ASLES	
Crossover Time			tc		120	1-1	
1) Pulse Test: PW - ; 2) f <sub>T</sub> =   she   f <sub>test</sub> *Indicates JEDEC Re	300 µs, Duty Cycle ≤2%. gistered Limit	001 55	A 052 - 30	) o	AWADI	2000 2021 40- 32RSV 34-	0,

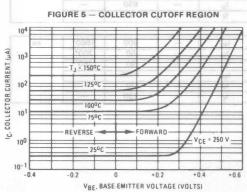


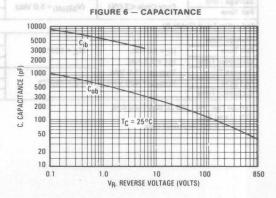




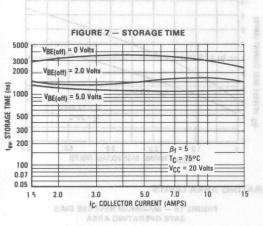


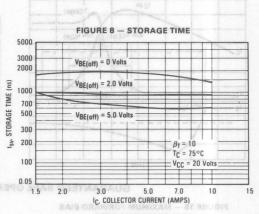
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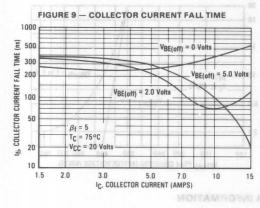


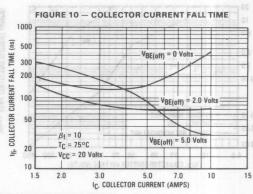


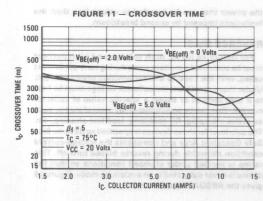
## THE SHOOT SEAS SEASY OF TYPICAL DYNAMIC CHARACTERISTICS AND THE STORY OF THE SHOOT











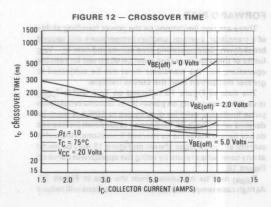
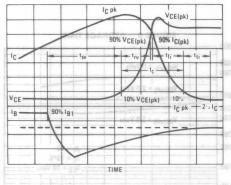
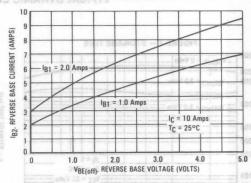


FIGURE 13 — INDUCTIVE SWITCHING MEASUREMENTS FIGURE 14 — PEAK REVERSE BASE CURRENT





#### **GUARANTEED SAFE OPERATING AREA LIMITS**

FIGURE 15 - MAXIMUM FORWARD BIAS SAFE OPERATING AREA

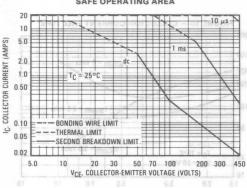
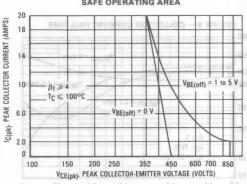


FIGURE 16 - MAXIMUM REVERSE BIAS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

## FORWARD BIAS REVOSEORS - ST BRUDGE

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

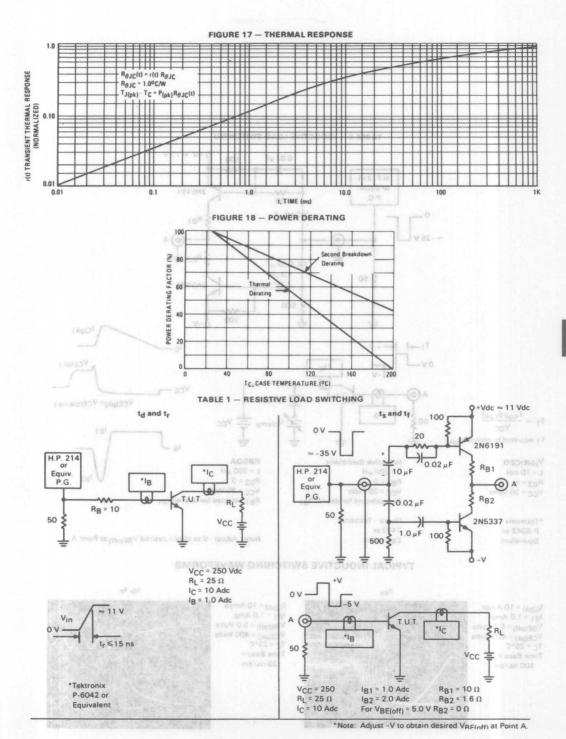
The data of Figure 15 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

TJ(pk) may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown

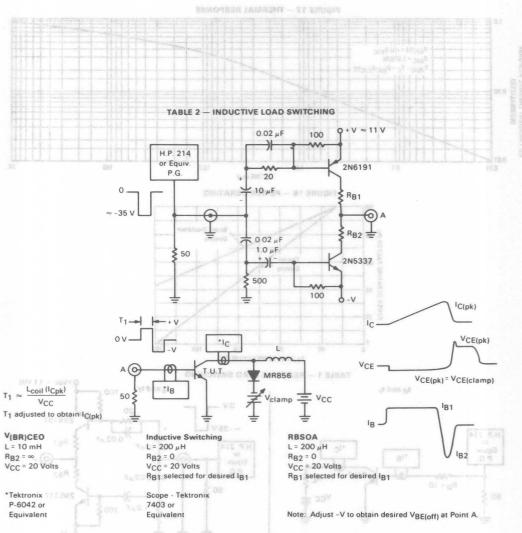
#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.

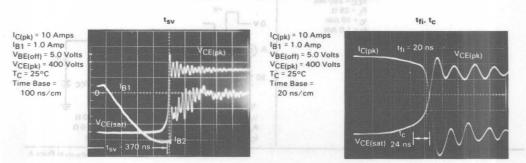








### TYPICAL INDUCTIVE SWITCHING WAVEFORMS





## Designer's Data Sheet

## SWITCHMODE III SERIES ULTRA-FAST NPN SILICON POWER TRANSISTORS

This transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

#### Typical Applications:

- Switching Regulators
- Inverters
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
   30 ns Inductive Fall Time 75°C (Typ)
   40 ns Inductive Crossover Time 75°C (Typ)
   800 ns Inductive Storage Time 75°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for:
   Reverse-Biased SOA with Inductive Loads
   Switching Times with Inductive Loads
   Saturation Voltages
   Leakage Currents

#### MAXIMUM RATINGS

Rating	Symbol	Max	Unit	
Collector-Emitter Voltage*	VCEO(sus)	450	Vdc	
Collector-Emitter Voltage*	VCEV	850	Vdc	
Emitter Base Voltage*	VEB	6.0	Vdc	
Collector Current — Continuous*  — Peak (1)	IC ICM	20 30	Adc	
Base Current — Continuous* — Peak (1)	I <sub>B</sub>	15 20	Adc	
Total Power Dissipation @ $T_C = 25^{\circ}C^*$ @ $T_C = 100^{\circ}C$ Derate above 25°C	PD	250 143 1.43	Watts W/°C	
Operating and Storage Junction* Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C	

#### \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit				
Thermal Resistance, Junction to Case*	R <sub>B</sub> JC	0.7	°C/W				
Maximum Lead Temperature for Soldering* Purposes: 1/8" from Case for 5 Seconds	TL	275	°C				

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle  $\leq$  10%.

\*Indicate JEDEC Registered Data

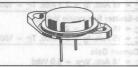
#### 20 AMPERE

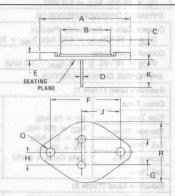
# NPN SILICON POWER TRANSISTORS

450 VOLTS 250 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



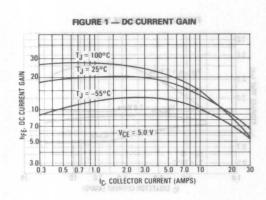


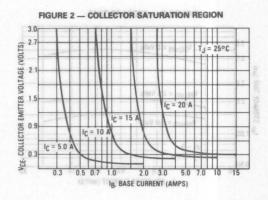
-10	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	(Zup	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

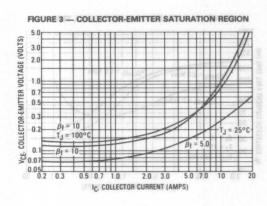
CASE 197-01 TO-204AE (Type) Modified TO-3

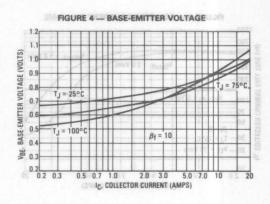
395	Characteristic	No. COMMENSE	Symbol	Min	Тур	Max	Unit
OFF CHARACTERI	STICS	-			and the second		
Collector-Emitter S (I <sub>C</sub> = 100 mA, I <sub>E</sub>	Sustaining Voltage (Table 3 = 0)	3 2)	V <sub>CEO(sus)</sub>	450*	_	_	Vdc
	rrent c, VBE(off) = 1.5·Vdc) c, VBE(off) = 1.5 Vdc, T		ICEV	E III SENI V POWER	PN SILICON	0.25* 1.5*	mAdc
Collector Cutoff Cu (V <sub>CE</sub> = 850 Vdc	rrent , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100	rawog (be	ICER	nigh <u>-v</u> oltag nere fall tin	e circuits wh	2.5	mAdc
Emitter Cutoff Cur (VEB = 6.0 Vdc,		- endice	IEBO	INDRIVE DO.	r iin <u>e-</u> opera	1.0*	mAdc
SECOND BREAKD	OWN PROFES		1			anoussilga	V residas
Second Breakdown	n Collector Current with	Base Forward Biased	IS/b		See Fig	gure 15*	ADTIVUE 0
Clamped Inductive SOA with Base Reverse Biased			RBSOA		See Fi	gure 16	msvril e
ON CHARACTERIS	STICS (1)		0			Controls	# Mictor
Collector-Emitter S (IC = 10 Adc, IB (IC = 15 Adc, IB (IC = 15 Adc, IB	= 1.2 Adc)	)	VCE(sat)	75°C (Typ)	es – Fall fine –	1.5 3.0* 3.0*	
Base-Emitter Satur (IC = 15 Adc, IB	ration Voltage		V <sub>BE</sub> (sat)	- 55 to +	Storago Tr atur <del>e</del> Range	1.5* and 1.5	003Vdc
DC Current Gain (IC = 15 Adc, V(IC = 20 Adc, V(IC =			hFE abs	7.5* 5.0	SOA with in	30*	Pevil Svviii
DYNAMIC CHARA	CTERISTICS (2)				8	age Current	dae I
Current Gain — Ba (VCE = 10 Vdc,	andwidth Product IC = 0.25 Adc, f <sub>test</sub> = 1	0 MHz)	fT	10*	_	75*	MHz
Output Capacitano (V <sub>CB</sub> = 10 Vdc,	e I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)		Cob	100*	_	500*	pF
SWITCHING CHAI	RACTERISTICS					200877	O DEMME
Resistive Load (Ta	ble 1)	Sold Long	its las	lmus		randon Si	
Delay Time	3	0 Vdc	td	want T	20	100*	ns
Rise Time	(I <sub>C</sub> = 15 Adc,	(I <sub>B2</sub> = 4.0 Adc,	tr	SCHOOL STATE	200	500*	at i nii antu
Storage Time	V <sub>CC</sub> = 250 Vdc,	$R_{B2} = 1.6 \Omega$	ts	107	1200	2700*	der Base Vo
Fall Time	I <sub>B1</sub> = 2.0 Adc, PW = 30 μs,	1 100	tf		200	350*	ator Curren
Storage Time	Duty Cycle ≤ 2.0%)	$(V_{BE(off)} = 5.0 \text{ Vdc})$	ts	101 -	650	(f) dos <del>(i)</del> —	
Fall Time	1	Ade A	tf	at -	80	Continuous	Current -
Inductive Load (Ta	ible 2)		8 1	481		Peak (1)	
Storage Time	RETENLENC)	O Wells	t <sub>sv</sub>	19	800	2700*	ns
Fall Time	(I <sub>C</sub> = 15 Adc,	$(T_C = 100^{\circ}C)$	tfi	_	50	200*	avoda diete
Crossover Time	IB1 = 2.0 Adc,	3° 005+	t <sub>C</sub>	1.17-	90	250*	bes going
Storage Time	VBE(off) = 5.0 Vdc,		tsv	_	1050	gne1	swiaragm
Fall Time	VCE(pk) = 400 Vdc)	$(T_C = 150^{\circ}C)$	tfi	-	70	MARACTER!	D JAMESH
Crossover Time	3.FL 18.BL 3	finU sa	t <sub>c</sub> los	- 2ym	120	Cloren <del>es</del> teriest	
(2) fT =  hfE  ftest	- 300 μs, Duty Cycle ≤ 2.0%		0 0.	Raji * Tı	to Case* for Solgaring	nos, Junetian	
*Indicates JEDEC Re	gistered Limit						

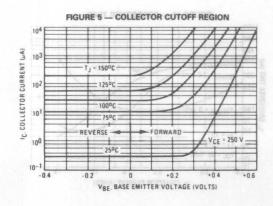
#### TYPICAL STATIC CHARACTERISTICS

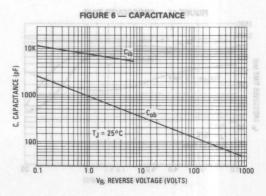




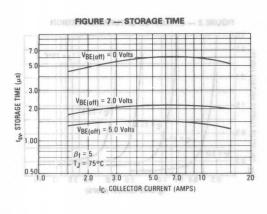


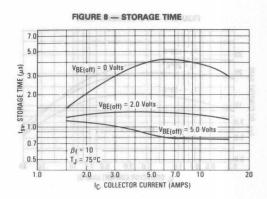


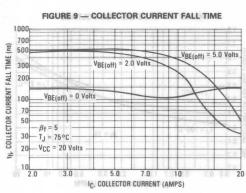


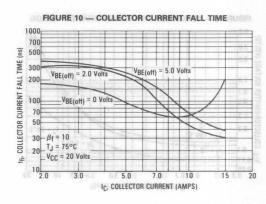


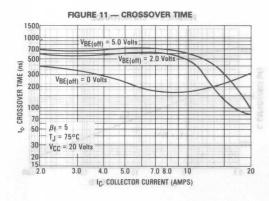
### TYPICAL DYNAMIC CHARACTERISTICS

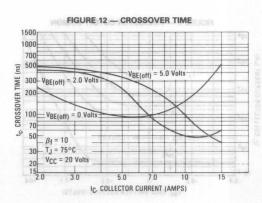




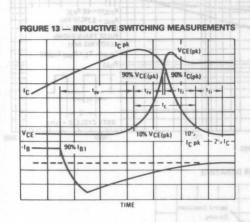


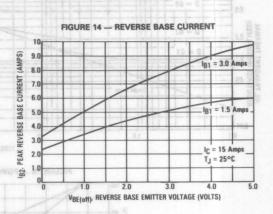




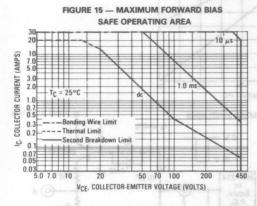


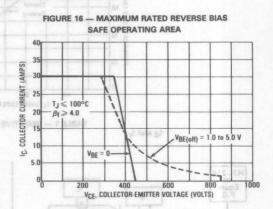






#### **GUARANTEED SAFE OPERATING AREA LIMITS**





#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 15 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \!\!>\!\! 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

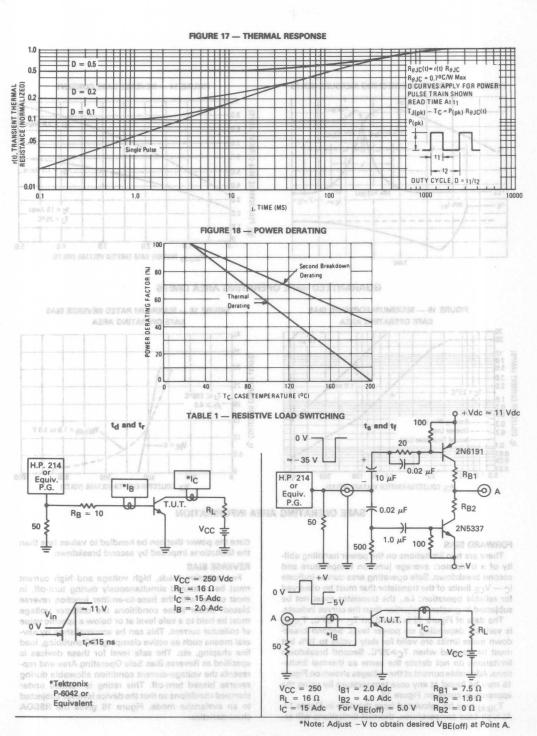
T<sub>J(pk)</sub> may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will re-

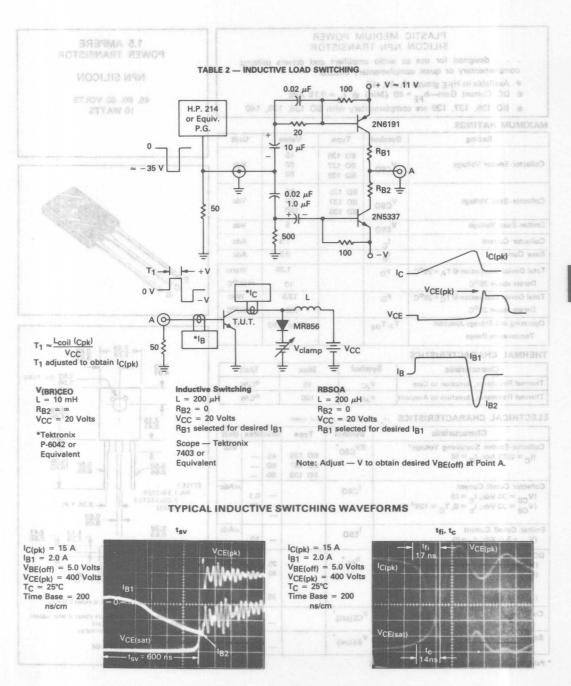
duce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.







## PLASTIC MEDIUM POWER SILICON NPN TRANSISTOR

. . . designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- Available in HFE groups -6, -10, -16
- DC Current Gain—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.15 Adc
- BD 135, 137, 139 are complementary with BD 136, 138, 140

#### **MAXIMUM RATINGS**

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	VCEO	BD 135 BD 137 BD 139	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 135 BD 137 BD 139	45 60 100	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	7	5	Vdc
Collector Current	¹c		1.5	Adc
Base Current	IB- 0	007	0.5	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	ol PD		1.25	Watts mW/ <sup>o</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		12.5	Watt mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	10	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	100	°C/W

## ELECTRICAL CHARACTERISTICS (1 25 C unless otherwise noted)

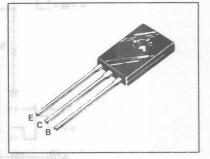
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.03 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub>	BD 135 BD 137 BD 139	45 60 80	=	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 125° C)	ICBO	MITCHIN	-	0.1	μ Adc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	<sup>1</sup> EBO		-	10	µAdc
DC Current Gain (I C = 0.005A, V CE = 2 V) (I C = 0.15A, V CE = 2 V) (I C = 0.5 A V CE = 2 V)	hFE 0.8	VER (off) = 2.0 VER (off) = 7.0 TC = 25°C	25 40 25	- 250 -	-
Collector-Emitter Saturation Voltage* ( I' <sub>C</sub> = 0.5 Adc, I <sub>R</sub> = 0.05 Adc)	V <sub>CE(sat)</sub>		-	0.5	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	V <sub>BE(on)</sub>		_	1	Vdc

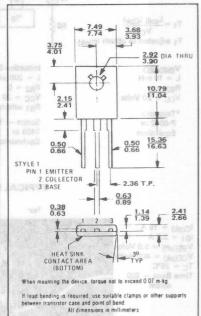
 $<sup>^{\</sup>circ}$  Pulse Test: Pulse Width  $\leq$  300 µs, Duty Cycle  $\leq$  2.0%

#### 1.5 AMPERE POWER TRANSISTOR

#### NPN SILICON

45, 60, 80 VOLTS 10 WATTS





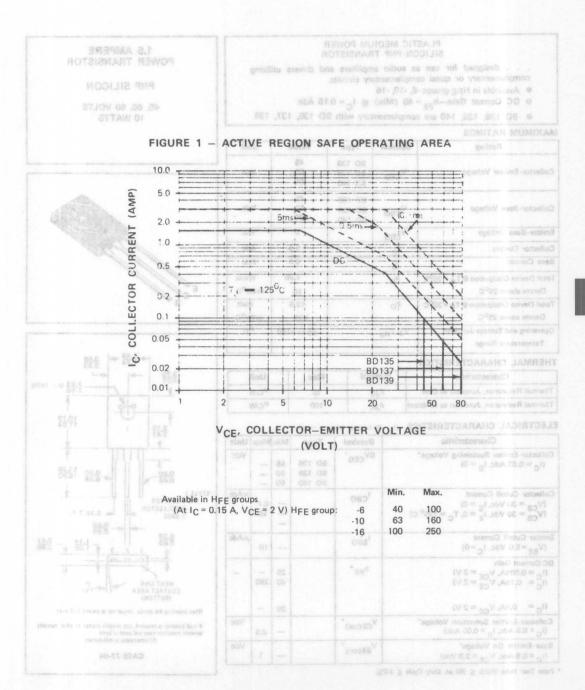
CASE 77-04

Table 10st. Table Width 2 500 ps, Day Cycle 2 2.0%

## BD135,-6,-10,-16, BD137,-6,-10,-16, BD139,-6,-10,-16



BD136,-6,-10,-16 BD138,-6,-10,-16 BD140,-6,-10,-16



3



## PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

. . . designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

Available in HFE groups -6, -10, -16

• DC Current Gain—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.15 Adc

BD 136, 138, 140 are complementary with BD 135, 137, 139

#### **MAXIMUM RATINGS**

Rating	Symbol	Type	Value	Unit
Collector-Emitter Voltage	VCEO	BD 136 BD 138 BD 140	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 136 BD 138 BD 140	45 60 100	Vdc
Emitter-Base Voltage	VEBO		5	Vdc
Collector Current	¹c	- 7	1.5	Adc
Base Current	1 <sub>B</sub>	- 30	0.5	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD		1.25	Watts m W/OC
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		12.5	mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Maoc	Unit
Thermal Resistance, Junction to Case	θЈС	10	ocw
Thermal Resistance, Junction to Ambient	θЈА	100	°C/W

#### ELECTRICAL CHARACTERISTICS (T 25 C unless otherwise noted)

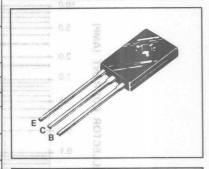
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.03 Adc, I <sub>B</sub> = 0)	BVCEO	BD 136 BD 138 BD 140	45 60 80	_	Vdc
Collector Cutoff Current $(V_{CB} = 30 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 30 \text{ Vdc}, I_E = 0, T_C = 125^{\circ} \text{ C})$	'сво от-	dnote 34)	<u></u>	0.1	μAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>		-	10	μAdd
DC Current Gain (I $_{\rm C} = 0.006$ A, $_{\rm VCE} = 2$ V) (I $_{\rm C} = 0.15$ A, $_{\rm VCE} = 2$ V) (I $_{\rm C} = 0.5$ A, $_{\rm VCE} = 2$ V)	h <sub>FE</sub> *		25 40 25	_ 250 _	-
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 0.5 Adc, I <sub>B</sub> = 0.05 Adc)	V <sub>CE(sat)</sub> *		-	0.5	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	V <sub>BE(on)</sub> °		-	1	Vdc

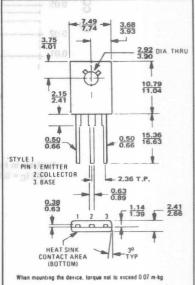
<sup>°</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

#### 1.5 AMPERE POWER TRANSISTOR

PNP SILICON

45, 60, 80 VOLTS 10 WATTS



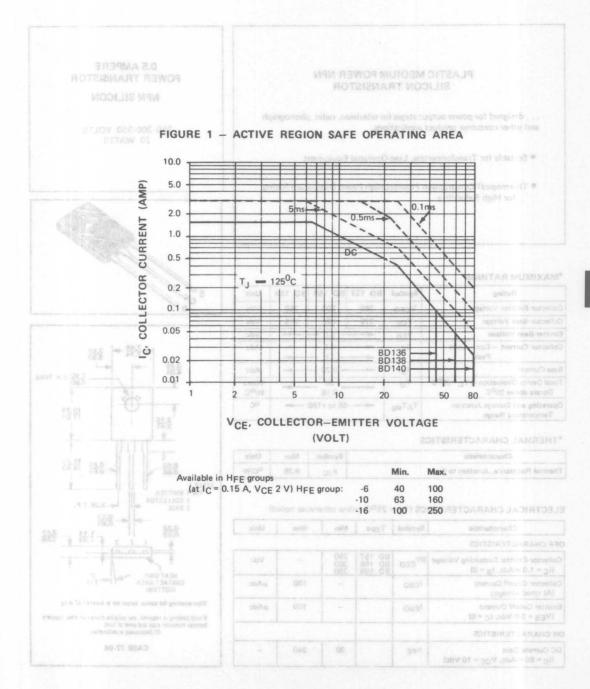


If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

CASE 77-04

3





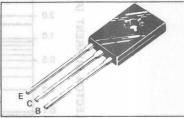
#### PLASTIC MEDIUM POWER NPN SILICON TRANSISTOR

. . . designed for power output stages for television, radio, phonograph and other consumer product applications.

- Suitable for Transformerless, Line-Operated Equipment
- Thermopad† Construction Provides High Power Dissipation Rating for High Reliability

## 0.5 AMPERE POWER TRANSISTOR **NPN SILICON**

250-300-350 VOLTS 20 WATTS



#### \*MAXIMUM RATINGS

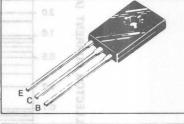
Rating	Symbol	BD 157	BD 158	BD 159	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	VCB	275	325	375	Vdc
Emitter-Base Voltage	VEB	-	— 5.0 —	-	Vdc
Collector Current - Continuous Peak	lc		- 0.5 - - 1.0 -		Adc
Base Current	1 <sub>B</sub>	18	— 0.25 —	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	-	20 0.16	1	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +150	0	°C

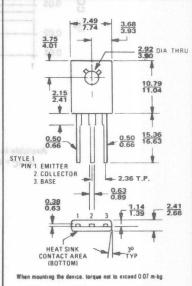
## \*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	6.25	°C/W

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Туре	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BV <sub>CEO</sub>	BD 157 BD 158 BD 159	250 300 350	-	Vdc
Collector Cutoff Current (At rated voltage)	СВО		-	100	μAdc
Emitter Cutoff Current (VEB = 5.0 Vdc, I <sub>C</sub> = 0)	IEBO		-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (IC = 50 mAdc, VCE = 10 Vdc)	pEE		30	240	-





If lead bending is required, use suitable clamps or other supports between transistor case and point of bend. All dimensions in millimeters

**CASE 77-04** 



FIGURE 1 - POWER TEMPERATURE DERATING CURVE

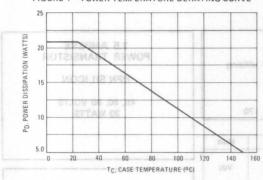


FIGURE 2 - "ON" VOLTAGES

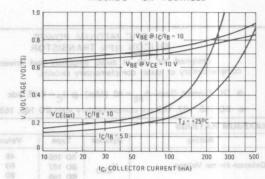
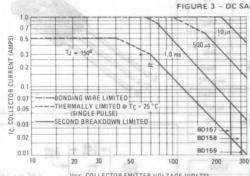


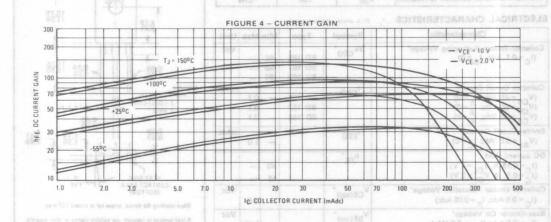
FIGURE 3 - DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate IC-VCE limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation Area to avoid causing a Catastrophic lentile. To history specially below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.

Thermal Riss rance, Junction to Case





NPN SILICON

45, 60, 80 VOLTS 20 WATTS

## PLASTIC MEDIUM POWER SILICON NPN TRANSISTOR

. . . designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.15 Adc
- BD 165, 167, 169 are complementary with BD 166, 168, 170

#### MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
Collector-Emitter Voltage	VCEO	BD 165 BD 167 BD 169	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 165 BD 167 BD 169	45 60 80	Vdc O - £ 3AU
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	¹c		1.5	Adc
Base Current	I <sub>B</sub>		0.5	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C		s Safe Oper the device		Watts mW/OC
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C		the avoid used the avoid use the maxim		Watt mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	DE REGIO NOT	-65 to +150	°C

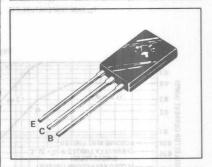
### THERMAL CHARACTERISTICS

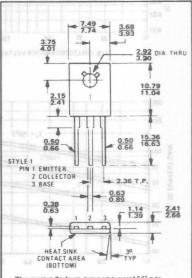
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	6:25	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	100	°C/W

## ELECTRICAL CHARACTERISTICS ... 1 25 C unless otherwise noted) US = 8 38

Characteristic	Symbol	Туре	Mir	Max	Unit
Collector-Emitter Sustaining Voltage* (1c = 0.1. Adc, 1g = 0)	BV <sub>CEO</sub> .	BD 165 BD 167 BD 169	45 60 80	=	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	Сво	BD 165 BD 167 BD 169	E	0.1 0.1 0.1	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO		E	1.0	mAdo
DC current Gain (I C = 0.15 A, V CE = 2 V) (I C = 0.5 A, V CE = 2 V)	h <sub>FE</sub> *		40	=	
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 0.5 Adc, I <sub>B</sub> = 0.05 Adc)	V <sub>CE(sat)</sub>	OE TMERBUD RO	105	0.5	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		-	0.95	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2 Vdc, f = 1.0 MHz)	f <sub>T</sub>		6.0	_	MHz

<sup>&</sup>lt;sup>o</sup> Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



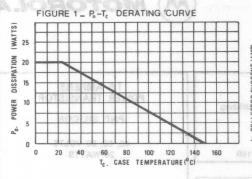


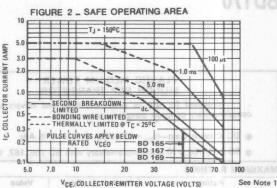
When mounting the device, torque not to exceed 0.07 m-kg

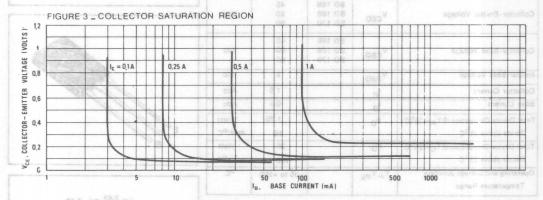
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend All dimensions in millimeters

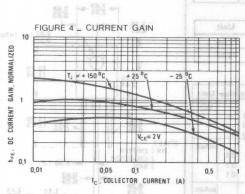
**CASE 77-04** 

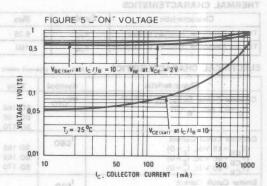
3











Note 1:
There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown.
Safe operating area curves indicate Ic - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on  $T_J(p_k)=150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(p_k) \leq 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

Pales Test: Poly: Width & Nile ya Diey Cycli & 10%



## PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

. . . designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.15 Adc
- BD 166, 168, 170 are complementary with BD 165, 167, 169

#### MAXIMUM RATINGS

f stold end Rating Tipy 3 SATION A	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 166 BD 168 BD 170	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 166 BD 168 BD 170	45 60 80	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	1 <sub>C</sub>		1.5	Adc
Base Current	B		0.5	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1	1.25	Watts mW/°C
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		20 160	Watt mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	(Ap) 789	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic BOATHOV A	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	6.25	°C/W
Thermal Resistance, Junction to Ambient	0.IA	100	°C/W

## ELECTRICAL CHARACTERISTICS (T\_ = 25°C unless otherwise noted)

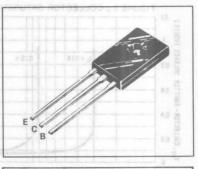
Characteristic	Symbol	Type	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BVCEO	BD 166 BD 168 BD 170	45 60 80		Vdc
Collector Cutoff Current (V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	СВО	BD 166 BD 168 BD 170	-	0.1 0.1 0.1	mAdd
Emitter Cutoff Current (V <sub>BF</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>	80 170	-	1.0	mAdo
DC current Gain (I = 0.15 A, V CE = 2 V) (I = 0.5 A, V CE = 2 V)	h <sub>FE</sub> *		40	n to	estilida Nastid
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 0.5 Adc, I <sub>R</sub> = 0.05 Adc)		handied breakdon	-	0.5	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 0.5 Adc, V <sub>CF</sub> = 2.0 Vdc)	V <sub>BE(on)</sub>		_	0.95	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2 Vdc, f = 1.0 MHz)	f <sub>T</sub>		6.0	_	MHz

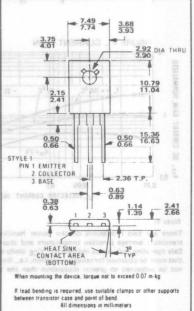
<sup>&</sup>lt;sup>o</sup> Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

#### 1.5 AMPERE POWER TRANSISTOR

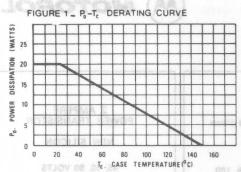
PNP SILICON

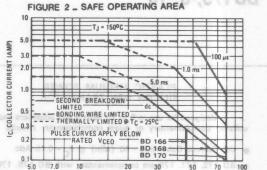
45, 60, 80 VOLTS 20 WATTS

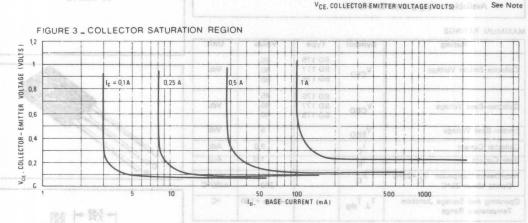


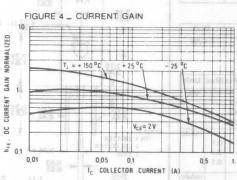


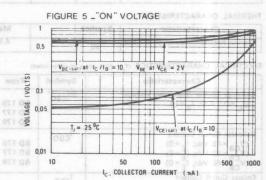
**CASE 77-04** 











Note 1:
There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on  $T_{J(pk)}=150^{o}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 100 provided  $T_{J(pk)} \leq 150^{o}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)



#### PLASTIC MEDIUM POWER SILICON NPN TRANSISTOR

designed for use in 5 to 10 Watt audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain— $h_{FE} = 40$  (Min) @  $I_{C} = 0.15$  Adc
- BD 175, 177, 179 are complementary with BD 176, 178, 180
- Available in HFE groups -6, -10, -16

#### MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
		BD 175	45	
Collector-Emitter Voltage	VCEO	BD 177	60	Vdc
	CEO	BD 179	80	
		BD 175	45	TI I
Collector-Base Voltage	V <sub>СВО</sub>	BD 177	60	Vdc
	CBO	BD 179	80	
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	¹c	1	3.0	Adc
Base Current	B		1.0	Add
Total Device Dissipation T <sub>C</sub> =25°C  Derate above 25°C	PD		30 240	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	(Am) TREAL	65 to +150	°C

#### THERMAL CHARACTERISTICS TOV "MO" & BRUDER

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	4.16	° C/W

#### ELECTRICAL CHARACTERISTICS (T\_ = 25°C unless otherwise noted)

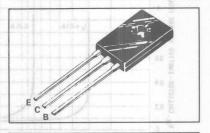
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BVCEO	BD 175 BD 177 BD 179	45 60 80		Vdc
Collector Cutoff Current (V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	СВО	BD 175 BD 177 BD 179	1	0.1 0.1 0.1	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>		-	1.0	mAdo
DC current Gain (I <sub>C</sub> = 0.15 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 1 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 1 A, V <sub>CE</sub> = 2 V)	FE OF CONTRACT	The da dapend for dua lamage	40 63 100 15	100 160 250	Nids p send br
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub>	hondler breakd	18 -0	0.8	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		-	1.3	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		3.0	_	MHz

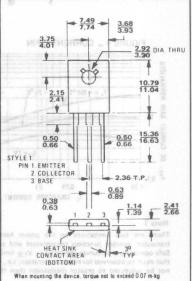
<sup>\*</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

### 3 AMPERE POWER TRANSISTOR

NPN SILICON

45, 60, 80 VOLTS 30 WATTS





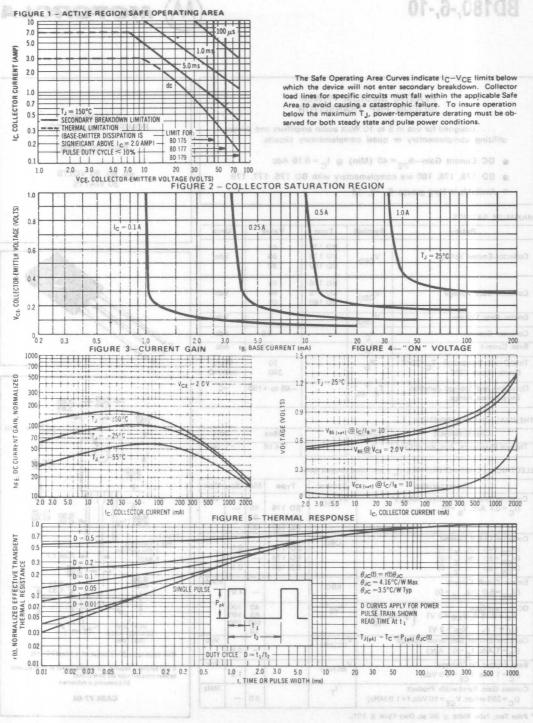
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

**CASE 77-04** 

BD176,-6,-10,-16







BD175,-6,-10,-16, BD177,-6,-10, BD179,-6,-10

# PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

. . . designed for use in 5 to 10 Watt audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain— $h_{FE} = 40$  (Min) @  $I_{C} = 0.15$  Adc
- BD 176, 178, 180 are complementary with BD 175, 177, 179
- Available in HFE groups -6, -10, -16

#### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 176 BD 178 BD 180	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 176 BD 178 BD 180	45 60 80	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	l <sub>C</sub>		3.0	Adc
Base Current	B	{Jul	1.0	Adc
Total Device Dissipation T <sub>C</sub> =25°C Derate above 25°C	P <sub>D</sub>		30 240	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θјς	4.16	° C/W

#### ELECTRICAL CHARACTERISTICS (T\_ = 25°C unless otherwise noted)

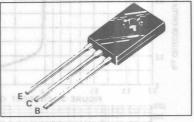
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>R</sub> = 0)	BV CEO.	BD 176	45	05 180	Vdc
	SENO983E	BD 178 BD 180	60 80	941U	OIT ITTE
Collector Cutoff Current (V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	СВО	BD 176 BD 178 BD 180		0.1 0.1 0.1	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO	m	-	1.0	mAdd
DC Current Gain (IC = 0.15 A, VCE = 2 V) (IC = 1 A, VCE = 2 V) (IC = 1 A, VCE = 2 V)	h <sub>FE</sub> *		40 63 100 15	100 160 250	
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub>		I S	0.8	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)	08 05	0.5	1.3	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		3.0	_	MHz

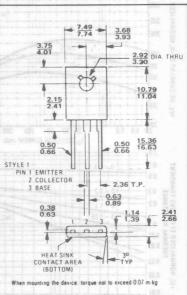
<sup>°</sup> Pulse Test: Pulse Width  $\leq$  300 µs, Duty Cycle  $\leq$  2.0%.

### 3 AMPERE POWER TRANSISTOR

PNP SILICON

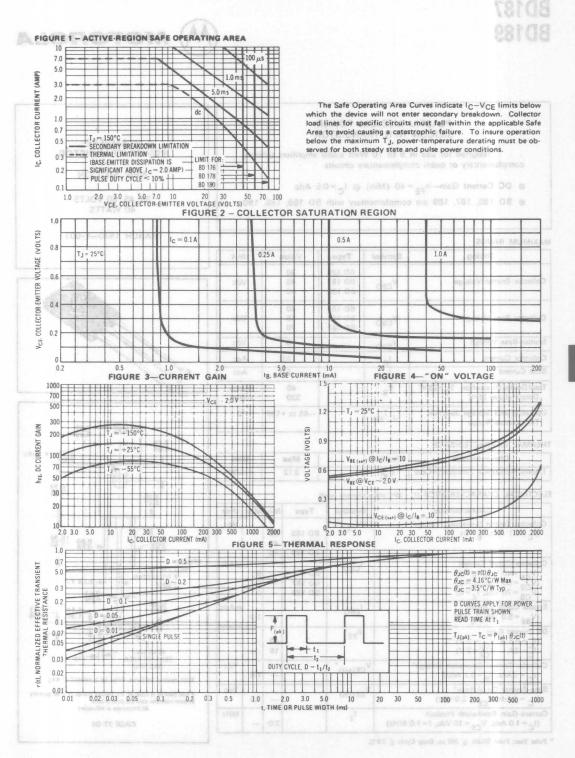
45, 60, 80 VOLTS 30 WATTS





If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.
All dimensions in millimeters.

**CASE 77-04** 





## PLASTIC MEDIUM POWER SILICON NPN TRANSISTOR

. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary or quasi complementary circuits.

- $\bullet$  DC Current Gain—h<sub>FE</sub> = 40 (Min)  $\otimes$  I<sub>C</sub> = 0.5 Adc
- BD 185, 187, 189 are complementary with BD 186, 188, 190

#### MAXIMUM BANGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 185 BD 187 BD 189	30 45 60	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 185 BD 187 BD 189	40 55 70	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	James	5	Vdc
Collector Current	l <sub>C</sub>		4.0	Adc
Base Current	B	(Am)	2.0	Adc
Total Device Dissipation T <sub>C</sub> =25°C	PD		40 320	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	2 1 1 1 1	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θјС	3.12	° C/W

#### ELECTRICAL CHARACTERISTICS (T = 25°C unless otherwise noted)

Characteristic	Symbol	Type	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub> *	BD 185 BD 187 BD 189	30 45 60		Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 55 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 70 Vdc, I <sub>E</sub> = 0)	Сво	BD 185 BD 187 BD 189	I	0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO		-	1.0	mAdc
DC current Gain (I <sub>C</sub> = 0.5 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 2A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *	11-1-0-00	40 15	H	
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 2Adc, I <sub>B</sub> = 0.2 Adc)	V <sub>CE(sat)</sub> *	y1 = 0 .139W	) Hue	1.0	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 2Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)	3.0 3.1	-	1.5	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		2.0	_	MHz

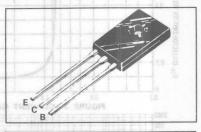
<sup>\*</sup> Pulse Test: Pulse Width  $\leq$  300 µs, Duty Cycle  $\leq$  2.0%.

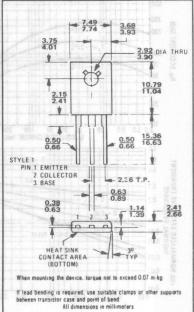
#### 4 AMPERE POWER TRANSISTOR

NPN SILICON

30, 45, 60 VOLTS 40 WATTS

MARCH 1970-E-003





**CASE 77-04** 

3-346

2.0

0.7

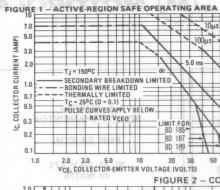
0.5

0.3

-55°C

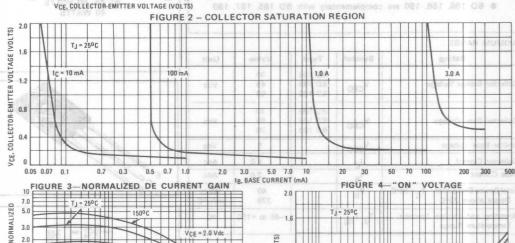


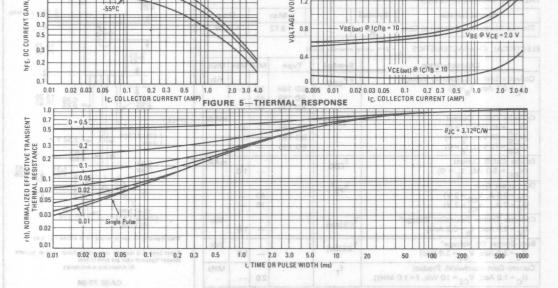
VBE @ VCE = 2.0 V



The Safe Operating Area Curves indicate I<sub>C</sub>-V<sub>CE</sub> limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.

@ DC Turient-her = 40 (Min) @ 1c = 0.5 Ade





VOLTAGE (VOLTS)

0.8



# PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary or quasi complementary circuits.

- $\bullet$  DC Current—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.5 Adc
- BD 186, 188, 190 are complementary with BD 185, 187, 189

#### MAXIMUM RANGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 186 BD 188 BD 190	30 45 60	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 186 BD 188 BD 190	40 55 70	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	1 11	5	Vdc
Collector Current	Ic		4.0	Adc
Base Current	I <sub>B</sub>	(6/23)	2.0	Adc
Total Device Dissipation Derate above 25°C	PD		40 320	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		65 to +150	°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θις	3.12	° C/W

#### ELECTRICAL CHARACTERISTICS (T = 2500 uples etherwise noted)

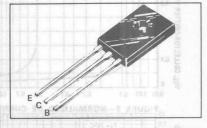
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub> .	BD 186 BD 188 BD 190	30 45 60	11 d	Vdc
Collector Cutoff Current  (VCB = 40 Vdc, IE = 0)  (VCB = 55 Vdc, IE = 0)  (VCB = 70 Vdc, IE = 0)	СВО	BD 186 BD 188 BD 190	1	0.1 0.1 0.1	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO		1	1.0	mAdo
DC current Gain (I <sub>C</sub> = 0.5 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 2 A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *		40 15		
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 0.2 Adc)	V <sub>CE(sat)</sub>		1	1.0	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	V <sub>BE(on)</sub> *	12 03 0	-	1.5	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>	LOTA 3630A1	2.0	-	MHz

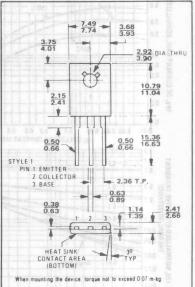
<sup>\*</sup> Pulse Test: Pulse Width  $\leq$  300 µs. Duty Cycle  $\leq$  2.0%.

### 4 AMPERE POWER TRANSISTOR

PNP SILICON

30, 45, 60 VOLTS 40 WATTS





If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

CASE 77-04

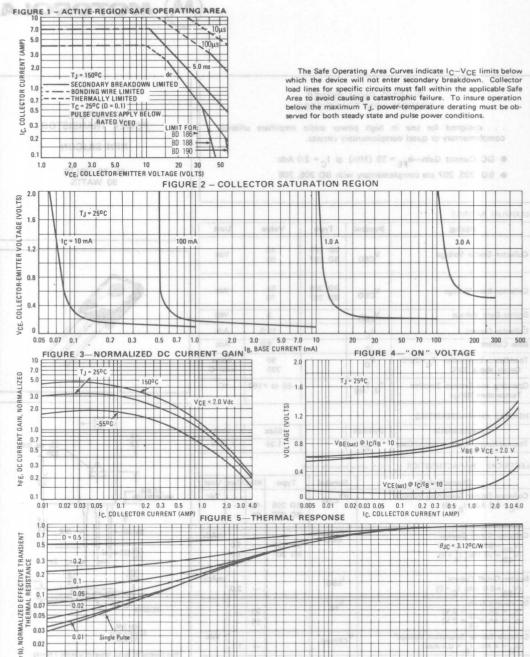
0.01

0.02 0.03 0.05

0.1

0.2 0.3

0.5 1.0



2.0 3.0

t, TIME OR PULSE WIDTH (ms)

5.0 10

100

50

200

1000

500



#### PLASTIC HIGH POWER SILICON NPN TRANSISTOR

. . . designed for use in high power audio amplifiers utilizing complementary or quasi complementary circuits.

- $\bullet$  DC Current Gain—h<sub>FE</sub> = 30 (Min) @ I<sub>C</sub> = 2.0 Adc
- BD 205, 207 are complementary with BD 206, 208

### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 205 BD 207	45 60	Vdc
Collector-Base Voltage	v <sub>СВО</sub>	BD 205 BD 207	55 70	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	l <sub>C</sub>		10.0	Adc
Base Current	1 <sub>B</sub>	(An)	6.0	, Adc
Total Device Dissipation T <sub>C</sub> =25°C	PD	T BILL	90 720	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		_55 to +150	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ <sub>IC</sub>	1.39	° C/W

### ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

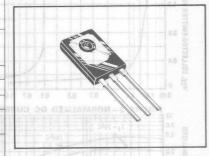
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)		BD 205 BD 207	45 60	000	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 55 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 70 Vdc, I <sub>E</sub> = 0)	Сво	BD 205 BD 207	Ē	1.0	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>		-	2.0	mAdc
DC current Gain (I <sub>C</sub> = 2A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 4A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *		30 15		
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.4 Adc)	V <sub>CE(sat)</sub> *			1.1	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 4 Adc, V <sub>CE</sub> = 2.0 Vdc)	V <sub>BE(on)</sub> *	ne 0.5 0		1.6	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>	10/9/323017	1.5	-	MHz

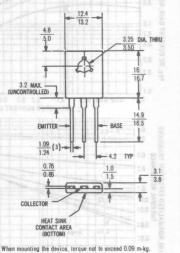
<sup>\*</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

### 10 AMPERE POWER TRANSISTOR

NPN SILICON

45, 60 VOLTS 90 WATTS





If lead bending is required, use suitable clamps or other supports between transistor case and point of bend. All dimensions in millimeters

CASE 90

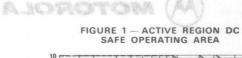
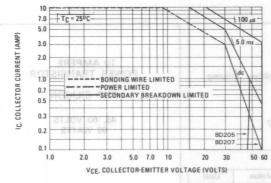
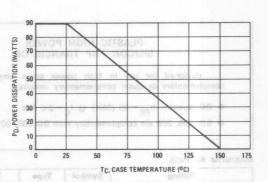
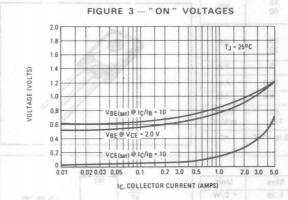
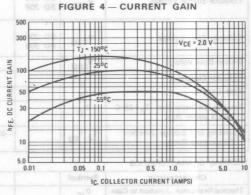


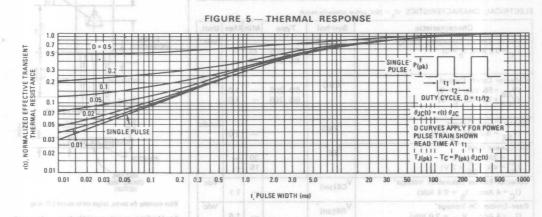
FIGURE 2 — POWER-TEMPERATURE DERATING CURVE











### PLASTIC HIGH POWER SILICON PNP TRANSISTOR

. . . designed for use in high power audio amplifiers utilizing complementary or quasi complementary circuits.

- DC Current— $h_{FF} = 30$  (Min) @  $I_{C} = 2.0$  Adc
- BD 206, 208 are complementary with BD 205, 207

### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	VCEO	BD 206 BD 208	45 60	Vdc
Collector-Base Voltage	v <sub>сво</sub>	BD 206 BD 208	55 70	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	4-1	5	Vdc
Collector Current	¹c		10.0	Adc
Base Current	I <sub>B</sub>	15 01	6.0	Adc
Total Device Dissipation T <sub>C</sub> =25°C Derate above 25°C	PD		90 720	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	01	_55 to +150	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	1.39	° C/W

### ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub> *	BD 206 BD 208	45 60	1	Vdc
Collector Cutoff Current (VCB = 55 Vdc, I <sub>E</sub> = 0) (VCB = 70 Vdc, I <sub>E</sub> = 0)	СВО	BD 206 BD 208	=	1.0	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>		-	2.0	mAdo
DC current Gain $(I_C = 2A, V_{CE} = 2 V)$ $(I_C = 4A, V_{CE} = 2 V)$	h <sub>FE</sub> *		30 15		H
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.4 Adc)	V <sub>CE(sat)</sub> *	EZ USA SE WIGHT (out	07.1	1.1	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 4 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)*		-	1.6	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		1.5	_	MHz

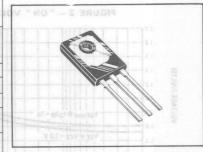
<sup>\*</sup> Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 2.0%.

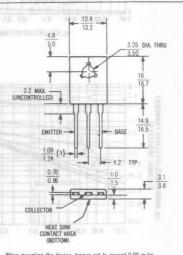
### 10 AMPERE POWER TRANSISTOR

PNP SILICON

45, 60 VOLTS 90 WATTS

2.6 3.6 5.0 10





When mounting the device, torque not to exceed 0.09 m-kg.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

CASE 90



FIGURE 1 - ACTIVE REGION DC SAFE OPERATING AREA

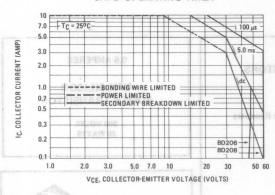


FIGURE 2 - POWER-TEMPERATURE **DERATING CURVE** 

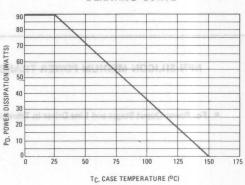


FIGURE 3 - "ON" VOLTAGES

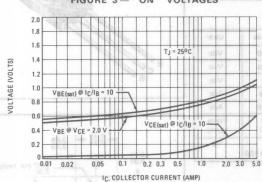
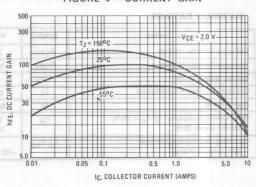
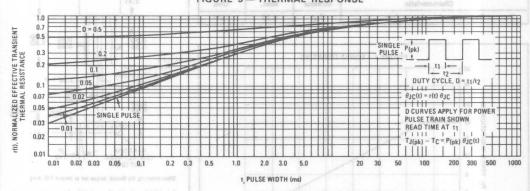


FIGURE 4 - CURRENT GAIN



THERMA L CHARACTERISTICS

FIGURE 5 - THERMAL RESPONSE



### NPN SILICON MEDIUM POWER TRANSISTORS

• For Power Ouput Stages and Line Driver in Television Receivers

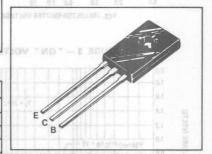
0.5 AMPERES

NPN SILICON POWER TRANSISTOR

> 300 VOLTS 20 WATTS

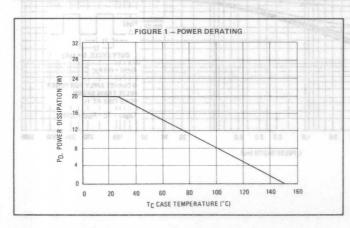
### MAXIMUM RATINGS

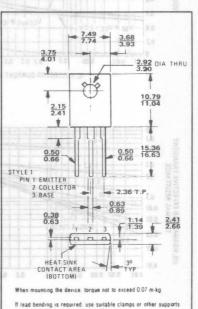
Rating	Symbol	Value	Unit'
Collector-Emitter Voltage	VCEO	300	Vdc
Collector-Emitter Voltage	VCES	500	Vdc
Emitter-Base Voltage	VEBO	5	Vdc
Co!lector Current — Continuous	Ic	0.5	Adc
Base Current	I <sub>B</sub>	0.25	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	20 160	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to 150	°C



#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	6.25	°C/W





ween transistor case and point of bend
All dimensions in millimeters

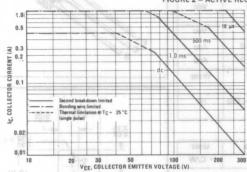
**CASE 77-04** 

3-354



Characteristic			Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS (1)	1					
Collector-Emitter Sustaining Voltage $(I_C = 10 \text{ mAdc}, I_B = 0)$				300		Vdc
Collector Cutoff Current (V <sub>CE</sub> = 500 Vdc, V <sub>BE</sub> = 0)	anevin		illica I <sub>CES</sub> us I	n 5 to 10 Wat or quesi com		
Base-Emitter Voltage $(V_{CE} = 5 \text{ Vdc}, I_{C} = 150 \text{ mA})$	858	ido 34, 238, 1	V <sub>BE</sub>	(niM) GP = 3 dnomelernos	1.0	Vdc
DC Current Gain $(V_{CE} = 5 \text{ V}, I_{C} = 50 \text{ mA})$ $(V_{CE} = 5 \text{ V}, I_{C} = 150 \text{ mA})$			hFE	25 20	150	игол мимки
Collector Emitter Saturation Voltage	that	sufaV	VCE(sat)	Symbol	gm	Vdc
$(I_C = 150 \text{ mA}, I_B = 15 \text{ mA})$	Vide	45	80 233		1.0	sam mili samaita
$(I_C = 150 \text{ mA}, I_B = 15 \text{ mA})$	967	45 60	80 233 80 233	- V	1.0	No. 1 Inch

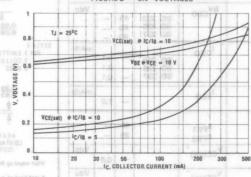
### FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 6 is based on  $T_{J(pk)}$  = 150 °C, TC is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{9}$ /o provided  $T_{J(pk)}$  = 150 °C.  $T_{J(pk)}$  may be calculated from the data in figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A)





(Ic=250 mAde, Vos=10 Vdc, (=1.0 MHz)



PLASTIC MEDIUM POWER

SILICON NPN TRANSISTOR

designed for use in 5 to 10 Watt audio amplifiers and drivers

- utilizing complementary or quasi complementary circuits.

   DC Current Gain—h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 0.15 Adc
- BD 233, 235, 237 are complementary with BD 234, 236, 238

2 AMPERE POWER TRANSISTOR

NPN SILICON

45, 60, 80 VOLTS 25 WATTS

MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
	Зуппоот	iype	value	Omit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 233 BD 235 BD 237	45 60 80	Vdc
Collector-Base Voltage	v <sub>CBO</sub>	BD 233 BD 235 BD 237	45 60 80	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	Thenc	5	Vdc
Collector Current	l <sub>C</sub>	riveob	2.0	Adc
Base Current	¹B	er elle	1.0	Adc
Total Device Dissipation T <sub>C</sub> =25°C	PD		25	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	ev ere Sq.)t.T	55 to +150	°C

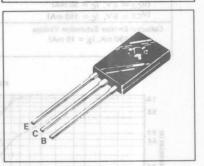
THERMAL CHARACTERISTICS

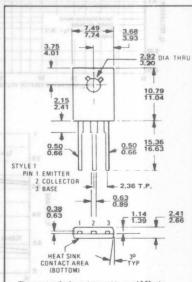
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	50	° C/W

ELECTRICAL CHARACTERISTICS (T\_ = 25°C unless otherwise noted)

Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub>	BD 233 BD 235 BD 237	45 60 80	=	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	СВО	BD 233 BD 235 BD 237	=	0.1 0.1 0.1	mAdo
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	EBO		-	1.0	mAdd
DC current Gain (I C = 0.15 A, VCE = 2 V) (I C = 1 A, VCE = 2 V)	h <sub>FE1</sub>		40 25		= \$1\y 2  
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub> °	601	-	0.6	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		-	1.3	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		3.0	-	MHz

Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.





When mounting the device, torque not to exceed 0.07 m-kg

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

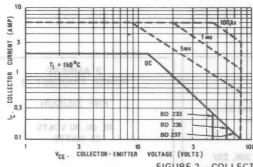
All dimensions in millimeters

**CASE 77-04** 

3

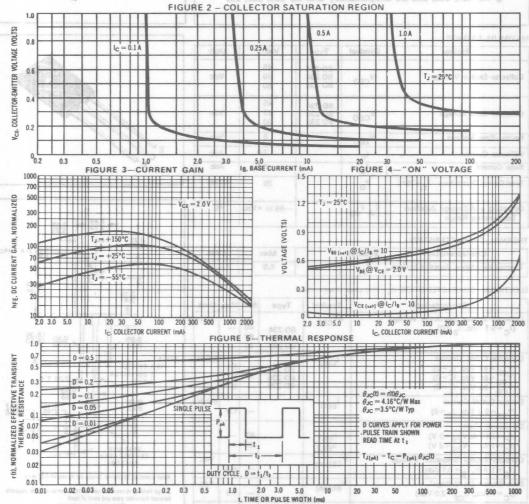
MOTOROLA





The Safe Operating Area Curves indicate  $I_C-V_{CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catestrophic failure. To insure operation below the maximum  $T_{J_c}$  power-temperature detaing must be observed for both steady state and pulse power conditions.

DC Current Sein-heg = 40 (Min) in 1g = 0.15





## PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

. . . designed for use in 5 to 10 Watt audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain— $h_{FE} = 40$  (Min) @  $I_{C} = 0.15$  Adc
- BD 234, 236, 238 are complementary with BD 233, 235, 237

### 2 AMPERE POWER TRANSISTOR

PNP SILICON

45, 60, 80 VOLTS 25 WATTS

#### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD 234 BD 236 BD 238	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD 234 BD 236 BD 238	45 60 80	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	¹c		2.0	Adc
Base Current TOATTON THO THE	I B	(An)	1.0 mg/s	Adc
Total Device Dissipation T <sub>C</sub> =25°C	PD		25	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		—55 to +150	°C

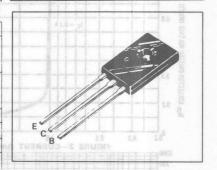
### THERMAL CHARACTERISTICS

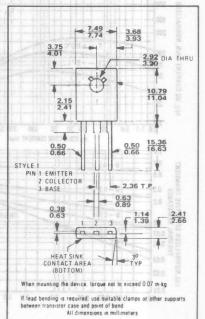
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θус	5.0	° C/W

### ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Type	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BV <sub>CEO</sub> *	BD 234 BD 236 BD 238	45 60 80	1001 1001 1-4-11	Vdc
Collector Cutoff Current (VCB = 45 Vdc, IE = 0) (VCB = 60 Vdc, IE = 0) (VCB = 80 Vdc, IE = 0)	Сво	BD 234 BD 236 BD 238		0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	I <sub>EBO</sub>	n	-	1.0	mAdc
DC current Gain (I <sub>C</sub> = 0.15 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 1 A, V <sub>CE</sub> = 2 V)	h <sub>FE1</sub>	1	40 25		
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub>		1=	0.6	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 2.0 Vdc)	V <sub>BE(on)</sub>	0.5 0.6 0 0.0 0.6 0	- L	1.3	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		3.0	-	MHz

<sup>\*</sup> Pulse Test: Pulse Width  $\leq$  300 µs, Duty Cycle  $\leq$  2.0%.

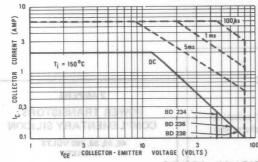




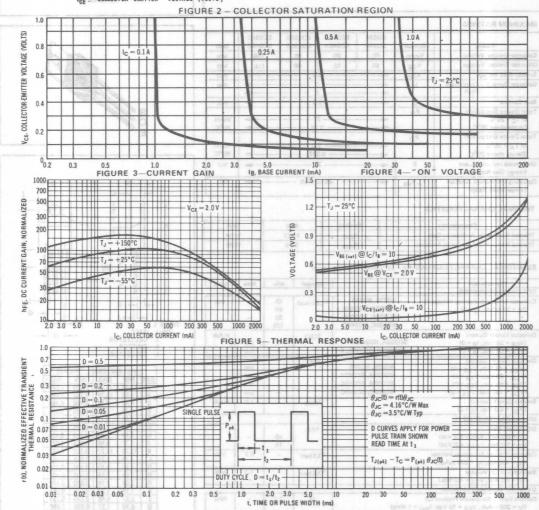
CASE 77-04

3-358





The Safe Operating Area Curves indicate  $I_{\rm C}-V_{\rm CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_{\rm J}$ , power-temperature derating must be observed for both steady state and pulse power conditions.



BD234, BD236, BD236

## COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

... designed for use in general purpose amplifier and switching applications. Compact TO-220 AB package. TO-66 leadform also available ordered with "66" suffix.

# 2 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

45, 60, 80, 100 VOLTS 30 WATTS

#### MAXIMUM RATINGS

Rating	Symbol	BD239 BD240	BD239A BD240A	BD239B BD240B	BD239C BD240C	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Emitter Voltage	VCB	55	70	90	115	Vdc
Emitter-Base Voltage	VEB	4	5	.0	-	Vdc
Collector Current - Continuous Peak	lc	2				Adc
Base Current	IB	0.6				Adc
Total Device Dissipation  © T <sub>C</sub> = 25°C  Derate above 25°C	PD	30				Watts W/°C
Total Device Dissipation  © T <sub>A</sub> = 25°C  Derate above 25°C	PD	2.0				Watts W/ <sup>O</sup> C
Unclamped Inductive Load Energy (See Note 3)	02 E	32 AMI YESHRUJ SAAR AI			mJ	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150				°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Resc	4.167	°C/W
Thermal Resistance, Junction to Ambient	ReJA	62.5	°CM

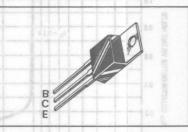
### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

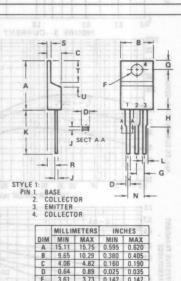
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS		0.3		1.00	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	BD239, BD240 BD239A, BD240A BD239B, BD240B BD239C, BD240C	VCEO(sus)	45 60 80 100		Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0) (VCE = 60 Vdc, IB = 0)	BD239A, BD240A BD239B,C, BD240B, C	ICEO	1967 - 1 <del>-</del> T	0.3	mAdc
Collector Cutoff Current (VCE = 45 Vdc, VEB = 0) (VCE = 60 Vdc, VEB = 0) (VCE = 80 Vdc, VEB = 0) (VCE = 100 Vdc, VEB = 0)	BD239, BD240 BD239A, BD240A BD239B, BD240A BD239C, BD240C	ICES		200 200 200 200	μAdc
	W(3 81 8 = 5/8	IEBO	111	1.0	mAdo
ON CHARACTERISTICS (1)					1 13
	PULSE HAIN THE THE APT.	pEE	40 15		TE
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 200 mAdc)	1-01-10-F	VCE(sat)	-	0.7	Vdc
Base-Emitter On Voltage (IC = 1.0 Adc, VCE = 4.0 Vdc)		VBE(on)	1-00	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain - Bandwidth Product (2) (IC = 200 mAdc, VCE = 10 Vdc, ftest	= 1 MHz)	and of Tave B	3.0	SAPT T	MHz
Small-Signal Current Gain (IC = 0.2 Adc, VCE = 10 Vdc, f = 1 kH	z)	h <sub>fe</sub>	20	-	-

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

(2) fT = Ihfe | o ftest

(3) This rating based on testing with L<sub>C</sub> = 20 mH, R<sub>BE</sub> = 100  $\Omega$ , R<sub>E</sub> = 0.1  $\Omega$ , I<sub>C</sub> = 1.8 A.





| DIM | MIN | MAX | MIN | MAX | A | 15.11 | 15.75 | 0.595 | 0.520 | 0.80 | 0.405 | C | 4.06 | 4.82 | 0.160 | 0.190 | D | 0.64 | 0.89 | 0.025 | 0.380 | 0.405 | F | 3.61 | 3.73 | 0.142 | 0.147 | G | 2.41 | 2.67 | 0.955 | 0.056 | M | 2.79 | 3.30 | 0.110 | 0.130 | J | 0.36 | 0.56 | 0.014 | 0.022 | K | 12.70 | 14.27 | 0.500 | 0.562 | L | 1.14 | 1.27 | 0.045 | 0.050 | N | 4.83 | 5.33 | 0.190 | 0.210 | Q | 2.54 | 3.04 | 0.100 | 0.120 | R | 2.04 | 2.79 | 0.080 | 0.110 | S | 1.14 | 1.39 | 0.045 | 0.055 | T | 5.97 | 6.48 | 0.235 | 0.255 | U | 0.76 | 1.27 | 0.030 | 0.055 |

CASE 221A-02 TO-220AB

FIGURE 1 - DC CURRENT GAIN

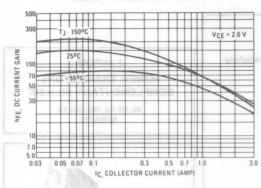


FIGURE 2 - TURN-OFF TIME

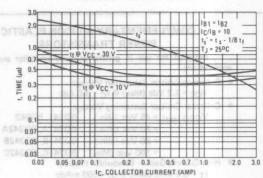
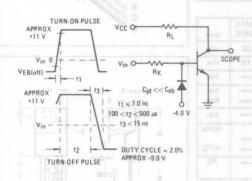


FIGURE 3 - SWITCHING TIME EQUIVALENT CIRCUIT



TO-58 Leadform Also Available ords
 TO-59 Total Available ords

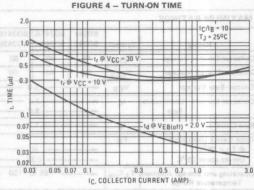
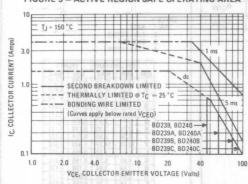


FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}$  =  $150^{\circ}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}$ C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).



### COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

designed for use in general purpose amplifier and switching applications.

 Collector-Emitter Saturation Voltage — VCE = 1.2 Vdc (Max) @ IC = 3.0 Adc

FIGURE 2 - TURN OFF TIME

Collector-Emitter Sustaining Voltage -

VCEO (sus) = 45 Vdc (Min.) BD241, BD242

= 60 Vdc (Min.) BD241A, BD242A

= 80 Vdc (Min.) BD241B, BD242B

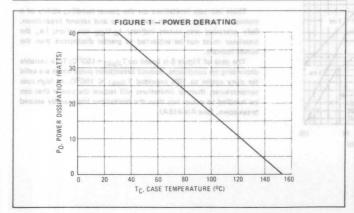
- = 100 Vdc (Min.) BD241C, BD242C • High Current Gain - Bandwidth Product
  - fT = 3.0 MHz (Min) @ IC = 500 mAdc
- Compact TO-220 AB Package
- TO-66 Leadform Also Available ordered with "-66" suffix.

### MAXIMUM RATINGS

Rating	Symbol	BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Emitter Voltage	VCES	55	70	90	115	Vdc
Emitter-Base Voltage	VEB	17.1	5.	0 -	-	Vdc
Collector Current - Continuous Peak	lc	3.0				Adc Adc
Base Current	18	1.0				Adc
Total Device Dissipation  © T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	40				Watts W/OC
Operating and Storage Junction Temperature Range	TJ, Tstg	18 10	- 65 to	+150 -	-	°C

#### THERMAL CHARACTERISTICS

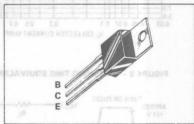
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	3.125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

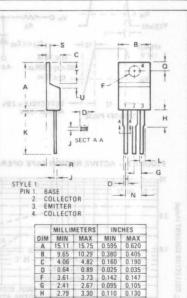


### 3 AMPERE

### POWER TRANSISTORS COMPLEMENTARY SILICON

45, 60, 80, 100 VOLTS 40 WATTS





DIM	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0,105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

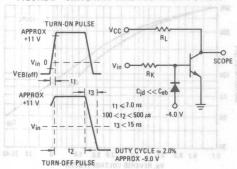
### ELECTRICAL CHARACTERISTICS (TC = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit.
DFF CHARACTERISTICS	FIGURE 4 - TH			
Collector-Emitter Sustaining Voltage BD241, BD242 (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0) BD241A, BD242A BD241B, BD242B BD241C, BD242C	VCEO	45 60 80 100		Vdc
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 60 Vdc, I <sub>B</sub> = 0) BD241, BD241A, BD242, BD242A, BD241B, BD241C, BD242B, BD242C	ICEO		0.3 0.3	mAdc
Collector Cutoff Current (VCE = 45 Vdc, VEB = 0) (VCE = 60 Vdc, VEB = 0) BD241, BD242 (VCE = 80 Vdc, VEB = 0) BD241A, BD242A (VCE = 80 Vdc, VEB = 0) BD241B, BD242B (VCE = 100 Vdc, VEB = 0) BD241C, BD242C	<sup>1</sup> CES		200 200 200 200 200	μAdc
Emitter Cutoff Current Opt 6.6 Or Oct 0 (VBE = 5.0 Vdc, IC = 0)	IEBO	5.0 1.	1.0	mAdc
ON CHARACTERISTICS <sup>1</sup> DC Current Gain  ABRA DMITARBSO BRAS MODI	hee	PIGURE		
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc)		25 10		
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 600 Adc), progressions over the small	VCE(sat)	2	1.2	Vdc
Base-Emitter On Voltage (I $_{\rm C}$ = 3.0 Adc, V $_{\rm CE}$ = 4.0 Vdc)	V <sub>BE(on)</sub>	KE	1.8	Vdc
DYNAMIC CHARACTERISTICS (STATE OF A STATE OF	MX	5985 ·	COUNDARY BINCASUS IMITED & Ty < 150°C HERMAL LIMIT & To	
Current Gain — Bandwidth Product <sup>2</sup> (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1 MHz)	fT	3.0	TIMIL BRING WINE	MHz
Small-Signal Current Gain (I <sub>C</sub> = 0.5 Adc, $V_{CE}$ = 10 Vdc, $f$ = 1kHz)	h <sub>fe</sub>	20	ATED VOED	W0.38 - 5.0

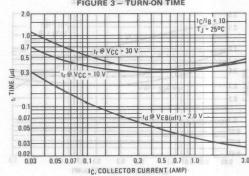
 $<sup>^{1}</sup>$  Pulse Test: Pulse Width  $\leqslant$  300  $\mu$ s, Duty Cycle  $\leqslant$  2.0%

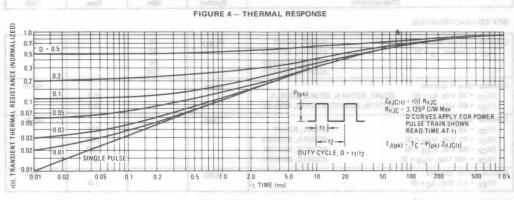
<sup>2</sup> f<sub>T</sub> = |h<sub>fe</sub>| • f<sub>test</sub>

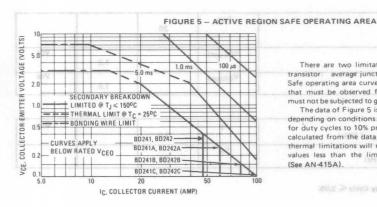
FIGURE 2 - SWITCHING TIME EQUIVALENT CIRCUIT







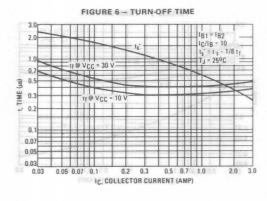


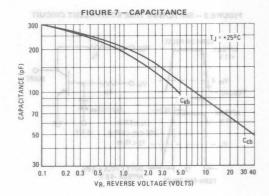


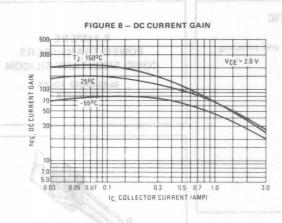
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate. IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

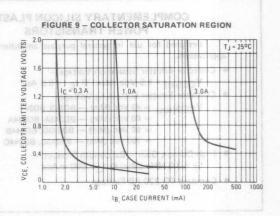
The data of Figure 5 is based on  $T_{J(pk)}=150^{o}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

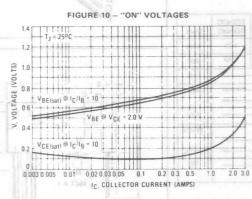
Profes Test: Poles Width ≤ 300 ys., Daty Cycle ≤ 2,0%

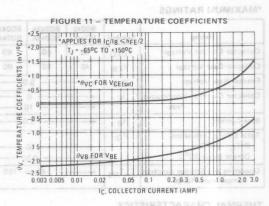


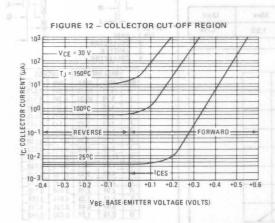












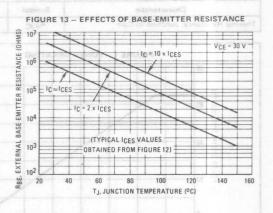


FIGURE 8 -- DC CURREN

### COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTORS**

designed for use in general purpose amplifier and switching applications.

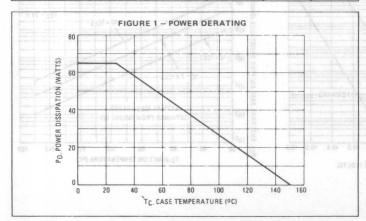
- Collector-Emitter Saturation Voltage -
  - VCE(sat) = 1.5 Vdc (Max) @ IC = 6.0 Adc
- Collector-Emitter Sustaining Voltage
  - VCEO(sus) = 45 Vdc (Min) BD243, BD244
    - = 60 Vdc (Min) BD243A, BD244A = 80 Vdc (Min) BD243B, BD244B = 100 Vdc (Min) BD243C, BD244C
- High Current Gain Bandwidth Product f<sub>T</sub> = 3.0 MHz (Min) @ I<sub>C</sub> = 500 mAdc
- Compact TO-220 AB Package

#### \*MAXIMUM RATINGS

Rating	Symbol	BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	100	Vdc
Emitter-Base Voltage	VEB	o <del>- yor</del>	5.	0	-	Vdc
Collector Current Continuous Peak	1C	6				Adc
Base Current	1 <sub>B</sub>	14 11	2	0	-	Adc
Total Device Dissipation  @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	RII <u>Z aun</u>	69		1	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	2,0 10.0	65 to	o +150 —	00 00 0	°C

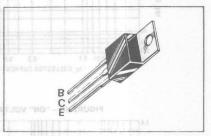
#### THERMAL CHARACTERISTICS

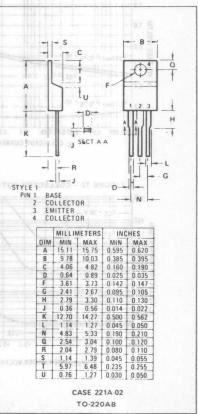
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.92	°C/W



### 6 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

45-60-80-100 VOLTS 65 WATTS



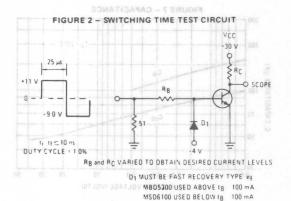


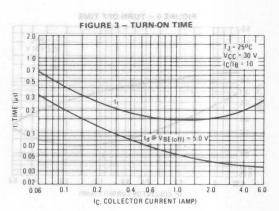
### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Character	istic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					0 110
Collector-Emitter Sustaining Voltage (1) (IC = 30 mAdc, IB = 0)	BD243, BD244 BD243A, BD244A BD243B, BD244B BD243C, BD244C	VCEO(sus)	45 60 80 100	- 5	Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0) (VCE = 60 Vdc, IB = 0)	BD243, BD243A, BD244, BD244A BD243B, BD243C, BD244B, BD244C	ICEO		0.7 0.7	mAdc
Collector Cutoff Current $(V_{CE}=45\ Vdc,\ V_{EB}=0)$ $(V_{CE}=60\ Vdc,\ V_{FB}=0)$ $(V_{CE}=80\ Vdc,\ V_{EB}=0)$ $(V_{CE}=100\ Vdc,\ V_{EB}=0)$	BD243, BD244 BD243A, BD244A BD243B, BD244B BD243C, BD244C	ICES		400 400 400 400	20Au
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	2.0 1.0 5.8 10 20 200 0.0 PULSE MAD TH (1931	D IEBO 2 T	6.0 50- 10	201.0208 52	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (IC = 0.3 Adc, VCE = 4.0 Vdc) (IC = 3.0 Adc, VCF = 4.0 Vdc) ABRA DAITABBBO BRAZ MOS		hFE BR-BVITQA -	30 39 15	_	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 6.0 Adc, I <sub>8</sub> = 1 Adc)		VCE(sat)	1-1	1.5	Vdc
Base-Emitter On Voltage (IC = 6.0 Adc, VCE = 4.0 Vdc)		VBE(on)	KIN	2.0	Vdc
DYNAMIC CHARACTERISTICS	Sale operating area curvi	my d		20081 -	
Current Gain — Bandwidth Product (2) (IC = 500 mAdc, VCE = 10 Vdc, ftee	t = 1 MHz) seed ton team	am to e <sup>†</sup> I	3.0 T I MA	SECOND BREAKDO	MHz
Small-Signal Current Gain. (IC = 0.5 Adc. VCE = 10 Vdc, f = 1)	decentions on conditions	hfe	3 3035 20 T MDI	TATIMEL #AREBRI	

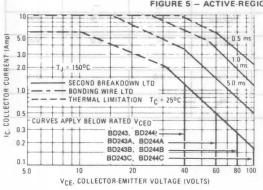
(1) Pulse Test: Pulsewidth ≤ 300 µs, Duty Cycle ≤ 2,0%.

(2) f T = hfer frest bezogmi znodutimil edi nadi zasl zeulev









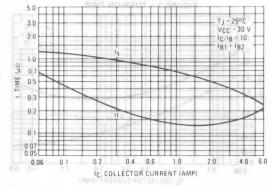
There are two limitations on the power handling ability of a transistor average junction temperature and second breakdown Safe operating area curves indicate IC VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate

ROJC(max) = 1.92°C/W

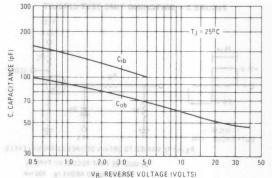
FIGURE 4 - THERMAL RESPONSE TO A STATE OF THE PROPERTY OF THE

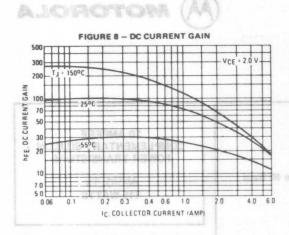
The data of Figure 5 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided TJ(pk)  $\leq$  150°C. TJ(pk) may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown (See AN-415A).

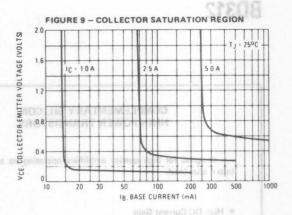




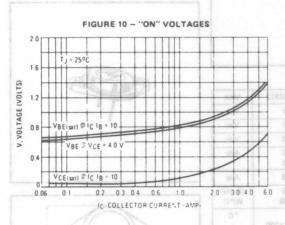
### FIGURE 7 - CAPACITANCE

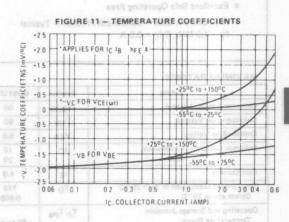


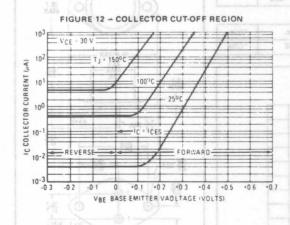


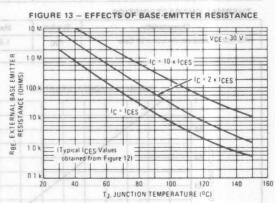


NPN









NPN **BD311 BD312** 

BD243, 243A, 243B, 243C, BD244, 244A, 244B, 244C



### **COMPLEMENTARY SILICON** HIGH-POWER TRANSISTORS

FIGURE 8 - COLLECTOR SATURAT

... designed for high quality amplifiers operating up to 60 Watts into 4 ohm load. 190 280 360 500

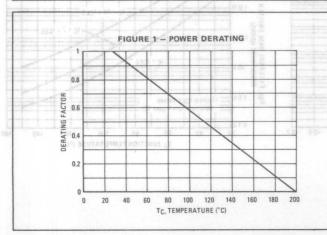
- High DC Current Gain
- Excellent Safe Operating Area
- High Current Gain Bandwidth Product Typical fT = 4.0 MHz @ IC = 0.5 A 1 374 BI OLD GASTINGS DE C

#### MAXIMUM RATINGS

Rating	Symbol	BD311/312	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Base Voltage	VCB	9 60	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous Peak	av Ic	10 20	Adc
Base Current	IB	4.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25 °C Derate above 25 °C	1 0 PD 30 0	115 0.658	Watts W/° C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

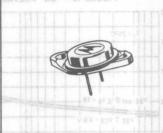
### THERMAL CHARACTERISTICS 33443 - 87 344514 MO1034

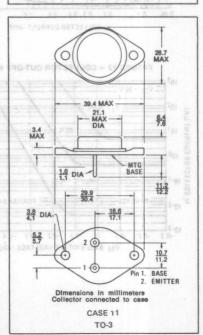
Characteristic	Symbol	Max.	Unit.
Thermal Resistance, Junction to Case	θЈС	1.52	°C/W



### 10 AMPERE **COMPLEMENTARY SILICON** POWER TRANSISTORS

60 VOLTS 115 WATTS





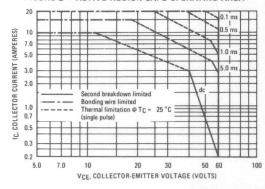
3

PNP DEVICE

### ELECTIRCAL CHARACTERISTICS\* (T<sub>C</sub> = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit.
OFF CHARACTERISTICS	CONTRACTOR OF THE PROPERTY OF			290
Collector-Emitter Sustaining Voltage <sup>1</sup> (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	60		Vdc
Collector-Base Cutoff Current (V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)	Ісво		1.0	mAdc
Emitter-Base Cutoff Current (VBE = 7.0 Vdc, I <sub>C</sub> = 0)	IEBO	EH!	1.0	mAdc
ON CHARACTERISTICS1		11-11		30
DC Current Gain (I <sub>C</sub> = 5.0 Vdc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)	HFE	25 5		
Collector-Emitter Saturation Voltage	VCE(sat)	1.0 2.0	1.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc)	V <sub>BE(sat)</sub>	DARI TREATUR	1.8	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	V <sub>BE</sub> (on)		1.5	Vdc
DYNAMIC CHARACTERISTICS <sup>1</sup>	milit et	11 111	1 1 3680 - 17	2.0
Current-Gain — Bandwidth Product <sup>2</sup> (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	fτ	4.0		MHz
SECOND BREAKDOWN	IN			
Second Breakdown Collector Current  (VCE = 39 Vdc, t = 0.5 sec.)  (VCE = 50 Vdc, t = 0.5 sec.)	I <sub>S/B</sub>	2.95 0.60	104 - 30 A 9 36 A - 81/31 a timi38 A	Adc
<sup>1</sup> Pulse test: Pulse width ≤ 300 μs, Duty Cycle ≥ 2% <sup>2</sup> f <sub>T</sub> = lhfel. f <sub>test</sub>				A.0
(na)30V		01 - 910	1 0 may 20 V	
0.2 0.2 0.3 0.7 1 2 3 6 10	30 50 70 11	10 20	0.2 0.1 06 0.1	1.0

### FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA

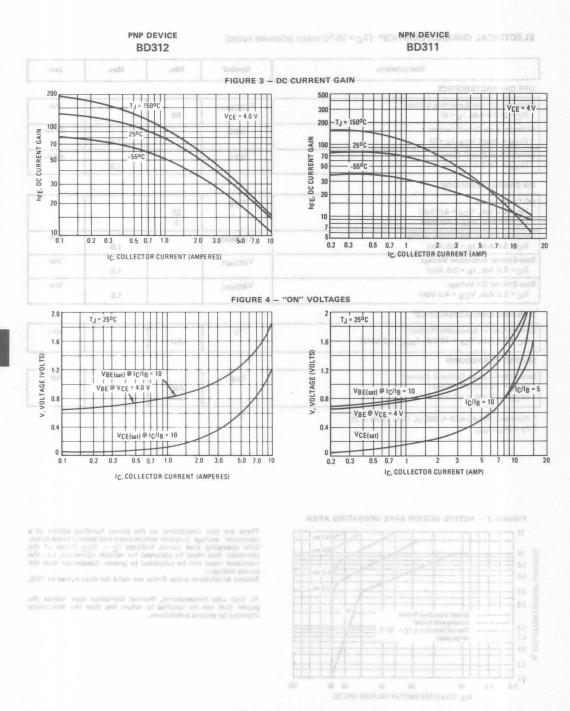


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> – V<sub>CE</sub> limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Second breakdown pulse limits are valid for duty cycles to 10%.

At high case temperatures, thermal limitation may reduce the power that can be handled to values less than the limitations imposed by second breakdown.







### COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

... designed for high quality amplifiers operating up to 100 Watts into 4 ohm load with BD315, BD316 and into 8 ohm load with BD317,

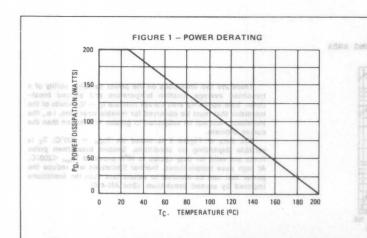
- High DC Current Gain
- Excellent Safe Operating Area
- High Current Gain Bandwidth Product Typical  $f_T = 2.0 \text{ MHz} @ I_C = 1.0 \text{ A}$

#### MAXIMUM RATINGS

Rating O.F.	Symbol	BD315 BD316	BD317 BD318	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	7.	0	Vdc
Collector Current - Continuous Peak	¹c	16		Adc
Base Current — Continuous	I <sub>B</sub>	5.	0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	20 1.1		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

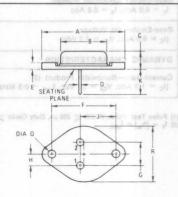
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.875	°C/W



### 16 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

80-100 VOLTS 200 WATTS





STYLET PIN 1. BASE
2. EMITTER NOTE
CASE: COLLECTOR 1. DIM "Q" IS DIA 1. DIM "Q" IS DIA

1	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A		39 37	, 1	1.550
В	VA 30	21.08	30	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	MAL E	3.43	A I served a	0.135
F	29.90	30.40	1 177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
1	16.64	17.15	0.655	0.675
K	11.18	12 19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	1	26.67	1-4	1.050

CASE 11 (TO-3)

9149

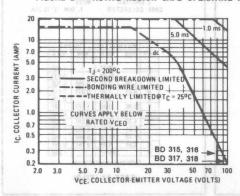


### \* ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	BD315, BD316 BD317, BD318	i diis	V <sub>CEO</sub> (sus)	80 100	d with 90315,	an Vdc
Collector-Base Cutoff Current $(V_{CB} = Rated V_{CB}, I_E = 0)$			Ісво	_	Current Cein	
Emitter-Base Cutoff Current (V <sub>BE</sub> = 7.0 Vdc, I <sub>C</sub> = 0)			I <sub>EBO</sub>	senA g	1.0	
ON CHARACTERISTICS (1)				A 0	- ole MHz (e) lc -	$S = \eta$
DC Current Gain $\begin{split} I_C &= 5.0 \text{ Adc, } V_{CE} = 4.0 \text{ Vdc} \\ I_C &= 8.0 \text{ Adc, } V_{CE} = 4.0 \text{ Vdc} \\ I_C &= 10 \text{ Adc, } V_{CE} = 4.0 \text{ Vdc} \end{split}$	BD317, BD318 BD315, BD316 All Types		h <sub>fE</sub>	25 25 15	YINGS	AS MUMIXA
Collector-Emitter Saturation Voltage $I_C = 8.0$ Adc, $I_B = 0.8$ Adc	tiaU	1317	V <sub>CE</sub> (sat)	lodinya	1.0	Vdc Vdc
	Vdc 1	.00	08	030V	ofraige	lactor-Emitter
Base-Emitter Saturation Voltage I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 0.8 Adc	Vde		V <sub>BE</sub> (sat)	Vcs	1.8	loV se Vdc rosi
ic o.o Ade, ig o.o Ade	Vdt		0.7	83V	1.0	itter-Base Volta
Base-Emitter On Voltage (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	Ade		V <sub>BE</sub> (on)	2	Continuous Pagl. 6.1	InstruVdc nos
DYNAMIC CHARACTERISTICS	Ade		5.0	E <sub>1</sub>	Continuous	e Current —
Current-Gain—Bandwidth Product (2) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 20 Vdc, f <sub>test</sub> = 0.5 MHz)	DQ/M		one or fr	1.0	Ples - 51 et nous	MHz
0 001892			-85 to +200	1 . 7	action of an	not2 has anits

(1) Pulse Test: Pulse Width  $\leqslant$  300  $\mu s$ , Duty Cycle > 2.0%. (2)  $f_T=|h_{te}|$   $\bullet$   $f_{test}$ .

FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA



ESIT - 1 20001

C. TEMPERATURE OCT

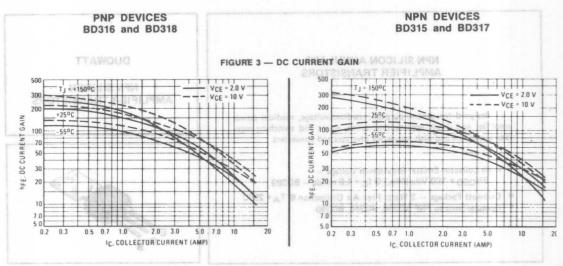
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm c} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate

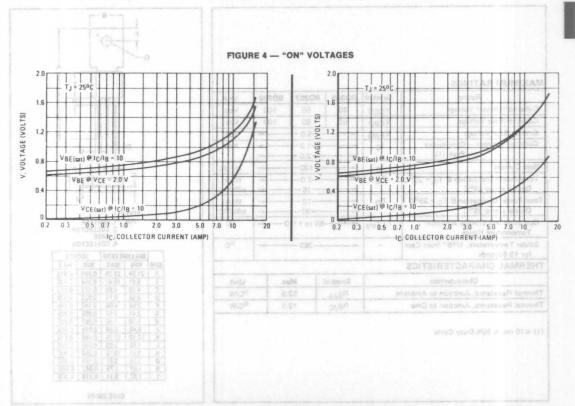
curves indicate.

The data of Figure 2 is based on  $T_{Jipkl} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{1/p}$  provided  $T_{Jipkl} < 200^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

3









## NPN SILICON ANNULAR® AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min.) @ IC = 1.0 mAdc BD389
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to PNP BD386, BD388, BD390

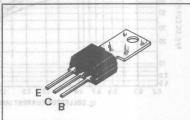
NPH DEVICES

BD315 and BD317

PNP DEVICES BD316 and BD318

DUOWATT

NPN SILICON
AMPLIFIER TRANSISTORS



3

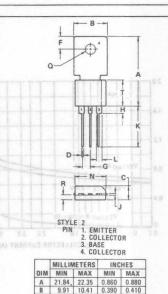
MOUBE 4 — "OH" VOLTAGES

MAXIMUM RATINGS					
Rating	Symbol	BD385	BD387	BD389	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCBO	60	80	100	Vdc
Emitter-Base Voltage	VEBO		-5.0 -	-	Vdc
Collector Current - Continuous - Peak (1)	1c	1.0		Adc	
Base Current	IB	100		mAdd	
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0		Watts mW/ <sup>O</sup> C	
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	TJ,T <sub>stg</sub>	0.0 X.0	-55 to +15	50 —	°C
Solder Temperature, 1/16" from Case for 10 Seconds	-	-	260	-	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	RθJC	12.5	°C/W

(1) ≤10 ms, ≤ 50% Duty Cycle



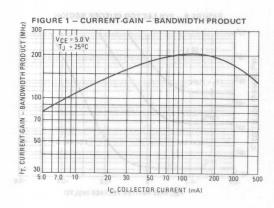
	MILLIN	ETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	21.84,	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
Н	1.70	1.96	0.067	0.07.7	
J	0.48	0.66	0.019	0.026	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
0	3.56	3.81	0.140	0.150	
R	1.07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

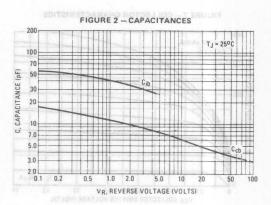
CASE 306-0

#### \*ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.)

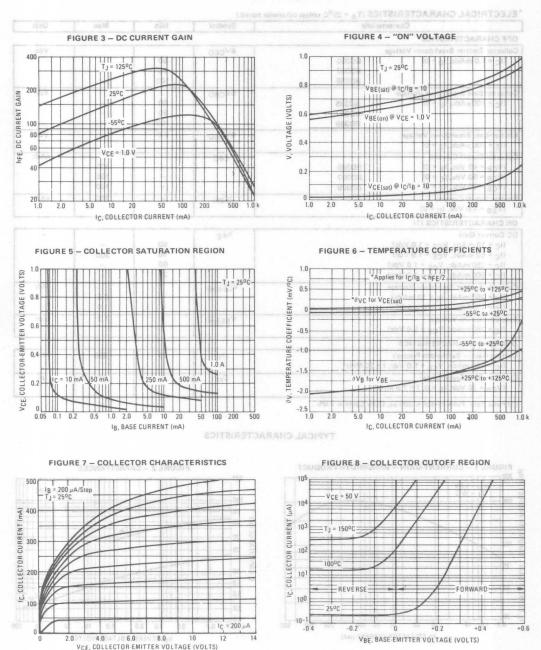
Character	Characteristic		Min	Max	Unit
OFF CHARACTERISTICS	SAUDIR		UPRENT GAIN	3 3 G - 8 3 R U D	9
Collector-Emitter Breakdown Voltage		BVCEO			Vdc
(I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD385	THE TAX A	60	CL. FPTT	
	BD387		80	Seal all	
	BD389		100		
Collector-Base Breakdown Voltage		BVCBO	allunas	2550	Vdc
(IC = 100 µAdc, IE = 0)	BD385		60		
	BD387		80	I I I I I I I I I I I I I I I I I I I	
	BD389		100	3408	
Emitter-Base Breakdown Voltage	THE A	BVEBO	5.0	HE WELT !	Vdc
(I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)					
Collector Cutoff Current		СВО		To Market	nAdc
(V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	BD385	11/1/11		100	
(VCB = 60 Vdc, IE = 0)	BD387			100	
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	BD389			100	
Emitter Cutoff Current		IEBO		100	nAdc
(V <sub>EB</sub> = 4.0 Vdc, I <sub>C</sub> = 0)	1,0 2.0 5,0	200 0.00 1.60 k		8 01 0.3	
ON CHARACTERISTICS (1)			Ward Income and	10/19/10/19	
DC Current Gain		pkE			-
(IC = 10 mAdc, VCE = 1.0 Vdc)		901039	60	100 mm = 100 mm	
(IC = 50 mAdc, VCE = 1.0 Vdc)	at - a ansact	2001023	80	300	
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc)			60		
(IC = 500 mAdc, VCE = 1.0 Vdc)			25		
Collector-Emitter Saturation Voltage	\$ 0.5	VCE(sat)		BE HALLE	Vdc
(IC = 250 mAdc, IB = 10 mAdc)				0.5	
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)			41111	1.0	
Base-Emitter On Voltage		VBE(on)	1 - 1 - 3 - 1 - 1	1.2	Vdc
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product		fT	75	350	MHz
(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 5.0 Vdc, f =	20 MHz)	ACIN		4 1 1 1 1 1 1	
Collector-Base Capacitance	rot give g	C <sub>cb</sub>	one A Alloes Y	18	pF
(VCB = 20 Vdc, IE = 0, f = 1.0 MHz	Maria de A			TI MINI	
(1) Pulse Test: Pulse Width ≤ 300 µs, Du				and the state of t	- CARL

### TYPICAL CHARACTERISTICS





### TYPICAL CHARACTERISTICS (continued)



MOTOFICE A

### TYPICAL CHARACTERISTICS (continued)

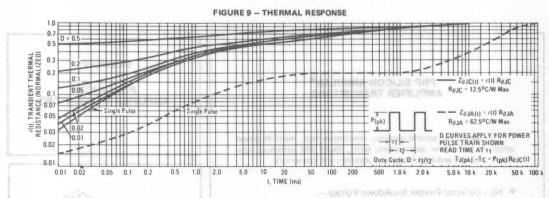
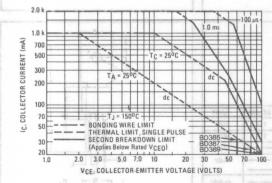


FIGURE 10 - ACTIVE-REGION SAFE-OPERATING AREA



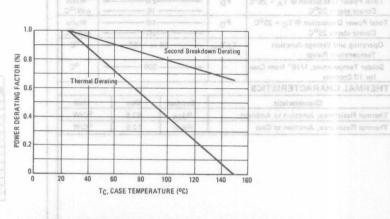
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Durwett Package - 2 Watts Free Air Distinction @ TA = 25°C

The data of Figure 10 is based on  $T_C=25^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

TJ(pk) may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 11 - POWER DERATING





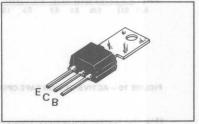
## PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc BD390
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to NPN BD385/BD387/BD389

DUOWATT

PNP SILICON AMPLIFIER TRANSISTORS



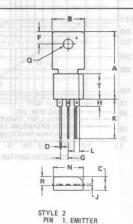
3

### MAXIMUM RATINGS

Rating	Symbol	BD386	BD388	BD390	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCBO	60	80	100	Vdc
Emitter-Base Voltage	VEBO	NOU 2001	<del></del> 50-	-	Vdc
Collector Current — Continuous Peak	lc	-	—1.0 — —2.0 —	-	Adc
Base Current	IB	-	<del></del>	-	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0		Watts mW/ <sup>O</sup> C	
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	ntress 8 bios	-55 to +15	60	°C
Solder Temperature, 1/16" from Case for 10 Seconds	-	-	<u>260</u>	$\times$	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	RθJC	12.5	°C/W



TYLE 2
PIN 1. EMITTER
2. COLLECTOR
3. BASE
4. COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
Q	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

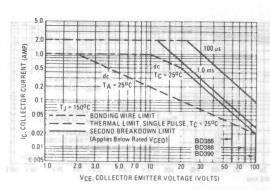
CASE 306-04

	*ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise n	oted.)
-1	Characteristic	1 9

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS .					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)  BD388 BD388 BD389	-14 01	BVCEO	60 80 100		Vdc
Collector-Base Breakdown Voltage (IC = 100 µAdc, IE = 0)  BD386 BD390  Emitter-Base Breakdown Voltage	20 00 00 00 00 00 00 00 00 00 00 00 00 0	BVCBO	60 80 100 5.0		Vdc
(I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)  Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0) BD388 (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0) BD390	10 y	Ісво	-	100 100 100	nAdc
Emitter Cutoff Current (VEB = 4.0 Vdc, IC = 0)	1.0 2	IEBO	OULTELL	100	nAdc
ON CHARACTERISTICS (1)		(A	mi TWARUS 601	10,001,80	
DC Current Gain (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)		hFE	60 80 60 25	300	
Collector Emitter Saturation Voltage (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)	1 344, 12 g	VCE(sat)	1 1	0.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)	De B	V <sub>BE</sub> (on)		1.2	Vdc
DYNAMIC CHARACTERISTICS	1 9	THE MAR	(   Aux 052   Am	905.] Am 92.   A	m 07 - 59
Current-Gain — Bandwidth Product (IC = 100 mAdc, VCE = 5.0 Vdc, f = 20 MHz).	25.1-25	fT	75	350	MHz
Collector-Base Capacitance (VCB = 20 Vdc, IF = 0, f = 1.0 MHz)	1.5U Ud.1 1	C <sub>cb</sub>		18	pF

<sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

### STMSIDITESOD SAUTAASEMST - 8 SA TYPICAL CHARACTERISTICS TABUTAS ACTUSION - A SAUGE



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)}$  =  $150^{\circ}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$  provided  $T_{J(pk)} \leqslant 150^{\circ}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 1 - ACTIVE REGION SAFE OPERATING AREA

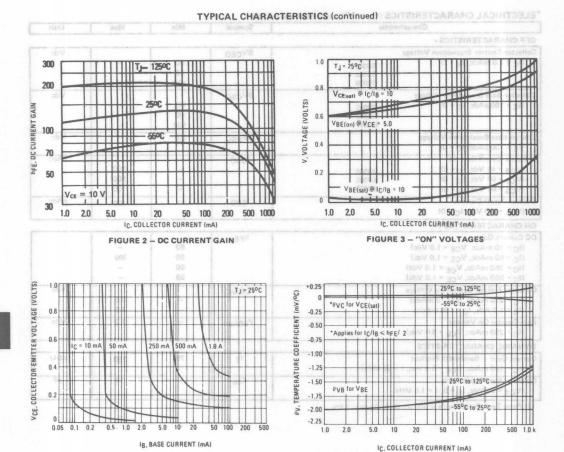
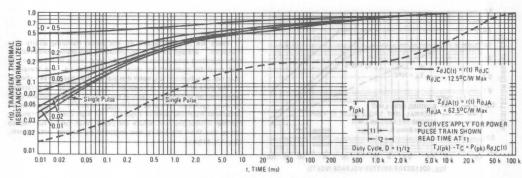
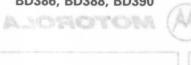
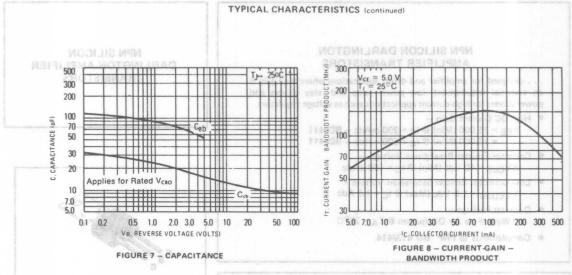


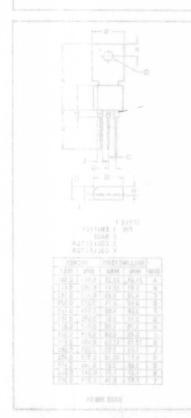
FIGURE 4 - COLLECTOR SATURATION REGION DAMAND JAC FIGURE 5 - TEMPERATURE COEFFICIENTS



ARA DINTAR FIGURE 6 - THERMAL RESPONSE







Plating	Symbol	Value	
Collector-Enviror Voltage	VCES	40	Vdc
	VCBO		
Emitter-Base Voltage	oasV 1		
Base Current - Continuous			
Total Power Dissipation © T <sub>A</sub> = 25°C Densite above 25°C		2.0 16	
Total Powe Dissipation@Tg = 25°C Derate above 25°C			Watts mW/ <sup>21</sup> C
Operating and Sturage Junction Temperature Range	173 T.LT		
Solder Temporature, 1/16" from Caso to: 10 Seconds		260	
HERMAL CHARACTERISTICS			
	Symbol		Unit
hermai Resir ance, Junction to Amblent			
		12.51	

## NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

TYPICAL CHARACTERISTICS continued

. . . designed for amplifier and driver applications where high gain is an essential requirement, low power lamp and relay drivers and power drivers for high-current applications such as voltage regulators.

• High DC Current Gain -

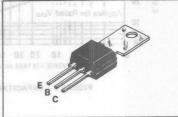
hFE = 25,000 (Min) @ IC = 200 mAdc - BD 411 = 15,000 (Min) @ IC = 500 mAdc - BD 411

- Collector-Emitter Breakdown Voltage BVCES = 40 Vdc (Min) @ IC = 100 μAdc
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 1.5 Vdc (Max) @ IC = 1.0 Adc
- Duowatt Package –

2 Watts Free Air Dissipation @ TA = 25°C

Complements to PNP BD 413/414

# NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

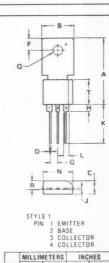


### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	VCEO	40	Vdc
Collector-Emitter Voltage	VCES	40	Vdc
*Collector-Base Voltage	V <sub>CBO</sub>	50	Vdc
*Emitter-Base Voltage	VEBO	12	Vdc
*Collector Current — Continuous	1c	2.0	Adc
*Base Current - Continuous	1 <sub>B</sub>	100	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0	Watts mW/ <sup>O</sup> C
Total Power Dissipation@T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	10 80	Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C
*Solder Temperature, 1/16" from Case for 10 Seconds	-	260	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W



	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84,	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.07.7
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

CASE 306-04

3

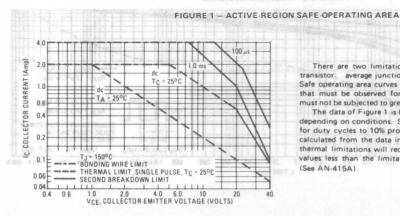
*FLECTRICAL	CHARACTERISTICS IT . = 25°C	nless otherwise noted.)	

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS			am menadira	e actions	
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 μAdc, V <sub>BE</sub> = 0)	2	BVCES	40	min	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	1	BVCBO	50		Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 µAdc, I <sub>C</sub> = 0)	(E)	BVEBO	12		Vdc
Collector Cutoff Current (VCB = 30 Vdc, IE = 0)	TO THE STATE OF TH	ІСВО	- 0.51	100	nAdc
Emitter Cutoff Current (VEB = 10 Vdc, IC = 0)	Adr	IEBO	5065	100	nAdc
ON CHARACTERISTICS (1)	THE	A MI			101
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc) BD411 BD412	1.0	hFE	25,000 15,000	150,000 150,000	3 0.0 2 0.0 3 0.0
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 5.0 Vdc) BD411 BD412 (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc) BD411 BD412		0. V 0.1 - 00V 10	15,000 10,000 5,000 3,000	100-31	0. 0.
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 4.0 mAdc)	0.	VCE(sat)	OHTARILTAZ RO	1.5 2.0	Vdc
Base-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 2.0 mAdc)	in the last	V <sub>BE</sub> (sat)		2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	n a-B	V <sub>BE</sub> (on)	-11	2.0	Vdc
DYNAMIC CHARACTERISTICS	110-10				10 10
High Frequency Current Gain (IC = 200 mAdc, VCE = 5.0 Vdc, f = 100 MHz)	Ke S	Ihfel	1.0 A 0.1 / Am 60	3 1 Ani 005	<b>I</b> III.;
(VCB = 10 Vdc, IE = 0, f = 1.0 MHz)	N 0 - H	Cob		7.0	pF
Small-Signal Current Gain $(I_C = 50 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 1.0 \text{ kHz})$ BD411 BD412	10.0 · 5	h <sub>fe</sub>	20,000 15,000	Am Qê	111112

Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

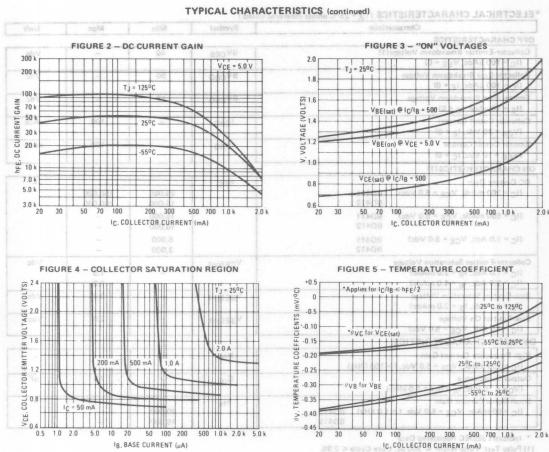
### TYPICAL CHARACTERISTICS

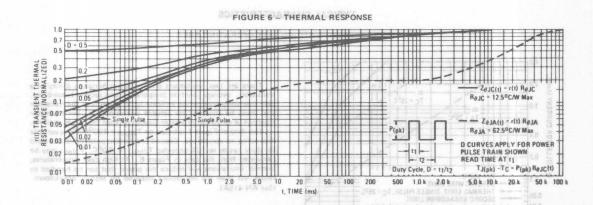


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $TJ(pk)=150^{O}C$ . To is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ(pk) \leqslant 150^{O}C$ . TJ(pk) may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).



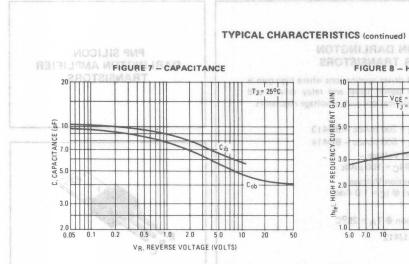


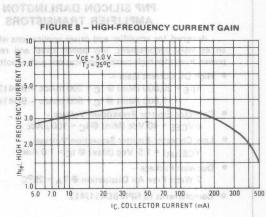


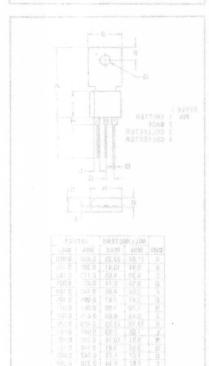












Collector-Emitter Voltage VCEO 40		
	0.0	
Collector En itter Voltage 40		
Collector-Sure Voltage 50	03	
Collector Current - Continuous (c 2.0		ala A
Total Power Distripution © TA = 25°C Pp 2.0 Derate above 25°C 16		
Total Power Dissipation @Tig = 25°C PD 10  Densite above 25°C 80		Water O'Viene
Operating 8: 5 Storage Junction T.J.Tstg -56 to +150 Tamperature Range		
Solder Tam, rature, 1/16" from Case for – 260	260	
HERMAL CHARACTERISTICS		
Characteristic Symbol Max	31.6394	tinti
hermal Repriseds Jungtion to Ambient Roda 62.5	62.5	
hermal Resistance, Junction to Case Road 12.6	125	



#### PNP SILICON DARLINGTON AMPLIFIER TRANSISTORS

TYPICAL CHARACTERISTICS (continued)

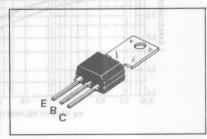
. designed for amplifier and driver applications where high gain is an essential requirement, low power lamp and relay drivers and power drivers for high-current applications such as voltage regulators.

• High DC Current Gain -

hFE = 20,000 (Min) @ IC = 200 mAdc - BD413 = 15,000 (Min) @ IC = 500 mAdc - BD414

- Collector-Emitter Breakdown Voltage -BVCES = 40 Vdc (Min) @ IC = 100 μAdc
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 1.5 Vdc (Max) @ IC = 1.0 Adc
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to NPN BD411/412

PNP SILICON DARLINGTON AMPLIFIER TRANSISTORS

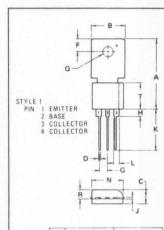


#### MAXIMUM RATINGS

	Value	Unit
VCEO	40	Vdc
VCES	40	Vdc
VCBO	50	Vdc
VEBO	12	Vdc
l <sub>C</sub>	2.0	Adc
1 <sub>B</sub>	100	mAdd
PD	2.0	Watts mW/ <sup>O</sup> C
PD	10 80	Watts mW/ <sup>O</sup> C
T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C
-	260	°C
	VCES VCBO VEBO IC IB PD	VCES 40 VCBO 50 VCBO 12 IC 2.0 IB 100 PD 2.0 I6 PD 10 80 TJ.Tstg -55 to +150

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	ocw
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

<sup>\*</sup>Indicates JEDEC Registered Data.



	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0 880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0 183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0 400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

CASE 306-04

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z	4	b
	г	9
г	3	Ð

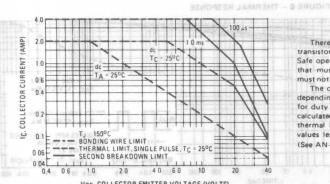
	Characteristic	Symbol	Min	Max
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Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 µAdc, V <sub>BE</sub> = 0)	BVCES	12 A A 140 3 G -	1 agus+1	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)	BVCBO	50	- x p.e - 1	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 μAdc, I <sub>C</sub> = 0)	BVEBO	12	3,621	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0)	СВО		100	nAdc
Emitter Cutoff Current VBB 30 VB 30	IEBO		100	nAdc
ON CHARACTERISTICS (1)	LZIIIII			OE E
DC Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc) BD413 BD414	hFE	20.000	150,000 150,000	= 1 m
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 5.0 Vdc) BD413 BD414	E 1111111	15,000 10,000	1.0 _20.0	10.02
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc) BD413 BD414	(15)	5,000 3,000	-10.001	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 4.0 mAdc)	VCE(sat)	-	1.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)	VBE(sat)	I HĀTI	2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	V <sub>BE</sub> (on)		2.0	Vdc
DYNAMIC CHARACTERISTICS				-WH 6
High Frequency Current Gain (IC = 200 mAdc, VCE = 5.0 Vdc, f = 100 MHz)	h <sub>fe</sub>	0.5		2 1 2 J
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 1.0 MHz)	C <sub>cb</sub>	A G 1 Am 60 d	Am 00.12	pF
Small-Signal Current Gain  (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 kHz) BD413  BD414	hfe	20,000		S C C C C C C C C C C C C C C C C C C C

<sup>\*</sup> Indicates JEDEC Registered Data

#### TYPICAL CHARACTERISTICS

#### FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA



VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

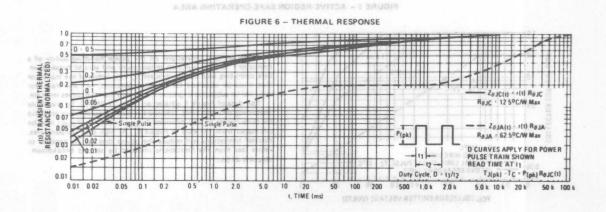
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on TJ(pk) = 150°C; TC is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ} C \cdot T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

<sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

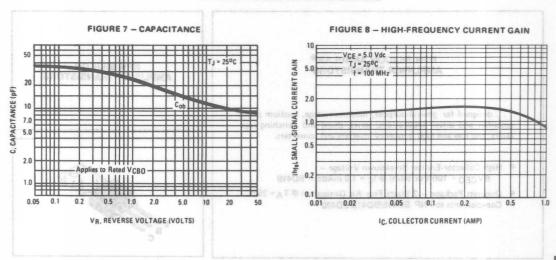


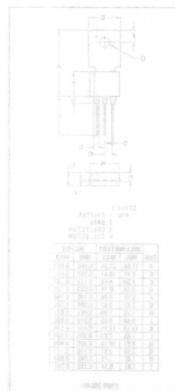
#### TYPICAL CHARACTERISTICS (continued) TERRETOARANS JASIATORIES FIGURE 3 - "ON" VOLTAGES FIGURE 2 - DC CURRENT GAIN 150 TJ = 250C VCE = 5.0 V 0001 GAIN (X 70 VOLTAGE (VOLTS) DC CURRENT ( 50 25°C 1.0 30 VCE(sat) @ IC/IB = 500 0.5 55°C 20 0 15 0.05 0.2 0.02 0.1 0.02 0.05 0.5 2.0 IC. COLLECTOR CURRENT (AMP) IC. COLLECTOR CURRENT (AMP) (1g = 1 0 Adc, 1g = 2.0 mAdc) FIGURE 5 - TEMPERATURE COEFFICIENT FIGURE 4 - COLLECTOR SATURATION REGION +0.8 32.0 LECTOR-EMITTER VOLTAGE (9.1 P. 1.5 P. 1 TEMPERATURE COEFFICIENT -0.8 VC FOR VCE(sat) -1.6 -2.4 -3.2 OVB FOR VBE -4 0 20 50 100 200 0.02 0.05 0.2 1.0 2.0 IB. BASE CURRENT (µA) IC. COLLECTOR CURRENT (AMP)





#### TYPICAL CHARACTERISTICS (continued)





AAXIMUM F THINGS				
	BD415			
	0.0			
		6.0	-	
				Ade
	2.0			
	08			
Operating and Storage Junction Yemperature force			-a ()(	
Solder Temperature, 1/16" from Care- for 10 Seconds			**************************************	
THERMAL CHARACTERISTICS				
Characteriatic	Symho	M I		
Thermal Registance, Junction to Ambiett				
Thermal Resistance, Junction to Case		1		W/30

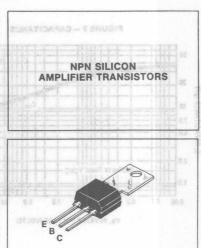
TYPICAL CHARACTERISTICS (continued)

# NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc BD419
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to PNP BD416/BD418/BD420

FIGURE 8 - HIGH FREQUENCY CURRENT GAIN



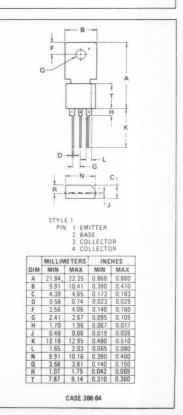
3

#### MAXIMUM RATINGS

Rating	Symbol	BD415	BD417	BD419	Unit
*Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCBO	(60	80	100	Vdc
Emitter-Base Voltage	VEBO	-	<del></del> 5.0	-	Vdc
Collector Current - Continuous Peak	lc	2.0			Adc
Base Current	1 <sub>B</sub>	-	<del></del>	-	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0		Watts mW/ <sup>O</sup> C	
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	55 to +150		°C	
Solder Temperature, 1/16" from Case for 10 Seconds	-	260		°C	

#### THERMAL CHARACTERISTICS

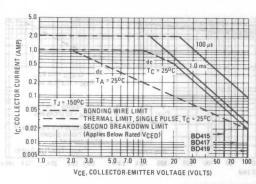
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Thermal Resistance, Junction to Case	RθJC	12.5	°C/W



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Characte	eristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					7 10 1
Collector-Emitter Breakdown Voltage		BVCEO			Vdc
(I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD415	THE TOTAL TOTAL PROPERTY.	60	HILL	
	BD417		80	114 37 333	
	BD419		100		00
Collector-Base Breakdown Voltage	Hara Barre	BVCBO			Vdc
(I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	BD415	- Hirtz	60	-41 H 3-41	
	BD417		80		
	BD419		100		
Emitter-Base Breakdown Voltage	HILL TO BE	BVEBO	5.0		Vdc
(I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)	H	TOTAL T		\$10 Bit - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
Collector Cutoff Current		СВО			nAdd
(V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	BD415	431111	10041	100	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	BD417	THE STATE OF THE S		100	
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	BD419		1111+	100	
Emitter Cutoff Current		IEBO		100	nAdd
(V <sub>EB</sub> = 4.0 Vdc, I <sub>C</sub> = 0)		280 900 1982	000 -04 1	6.8 10 8	
ON CHARACTERISTICS (1)	.31		(Am) THRRENT ROT	DE1189 Pt	
DC Current Gain	BRUDIR	hFEASAS	EWSRITUD DO -	FIGURE 2	_
(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc)			60	-	
(IC = 50 mAdc, VCE = 1.0 Vdc)			80	300	
(IC = 250 mAdc, VCE = 1.0 Vdc)			60	- 1	
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)			25		
Collector-Emitter Saturation Voltage		VCE(sat)	THE DIRECT	THE STREET	Vdc
(I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc)	Fig Applies for IC/IB < he			0.5	
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)				1.0	
Base-Emitter On Voltage	n 2	V <sub>BE</sub> (on)		1.2	Vdc
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)					
DYNAMIC CHARACTERISTICS	1 1 1		orl acoelano	es   Am Ge   Am	GI 17   1   1   1   1
Current-Gain - Bandwidth Product	5	fT	75	350	MHz
(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 5.0 Vdc, f	= 20 MHz)				
Collector-Base Capacitance	1 27 W S/P	Cob		12	pF
(VCB - 10 Vdc, IE = 0, f - 1.0 MH	J-1			A DOMESTIC OF	

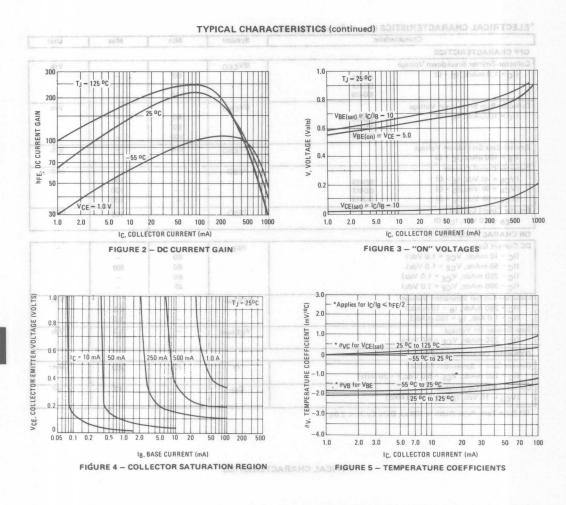
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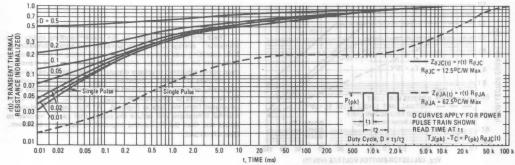


There are two limitations on the power-handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be observed to greater dissipation than the curves indicate. The data of Figure 1 is based on  $TJ(pk)=150^{\rm OC}$ ;  $T_{\rm C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ(pk)\approx150^{\rm OC}$ . TJ(pk) may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA





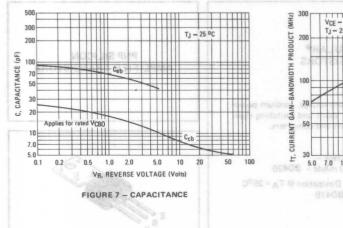
A 3RA CHITA FIGURE 6 - THERMAL RESPONSE

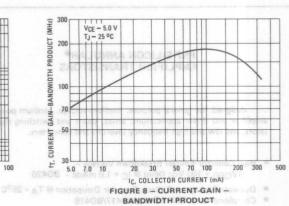


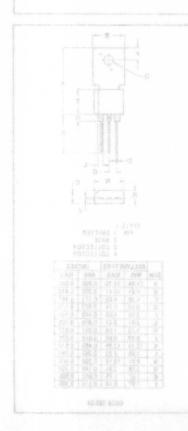


BD416 BD418 BD420

TYPICAL CHARACTERISTICS (continued)







	Symbol [	athea			
	VCEO				
	Vcso	08			
		-		40	
oral Power C. siperion @ To = 25°C. Derate above 25°C.			01	-	
Operating and Storage Junction Temperature Range		-			
Solder Temperature, 1/16" from Case for 10 Seconds			260		
			M I	20	

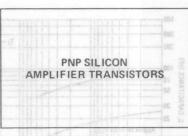
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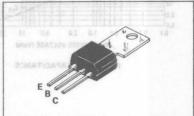


## PNP SILICON ANNULAR\* AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

- High Collector-Emitter Breakdown Voltage BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc - BD420
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C
- Complements to NPN BD415/BD417/BD419





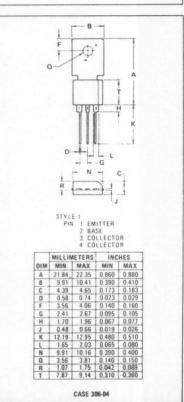
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#### MAXIMUM BATINGS

Rating	Symbol	BD416	BD418	BD420	Unit
Collector-Emitter Voltage	VCEO	EO 60 80 100		100	Vdc
Collector-Base Voltage	VCBO	60	80	100	Vdc
Emitter-Base Voltage	VEBO	4	<del></del> 5.0	-	Vdc
Collector Current - Continuous Peak	lc lc	1.0			Adc
Base Current	I <sub>B</sub>	100			mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2.0			Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	10		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-55 to +15	50 —	°C
Solder Temperature, 1/16" from Case for 10 Seconds	-	-	— 260 —	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	Rejc	12.5	oC/M

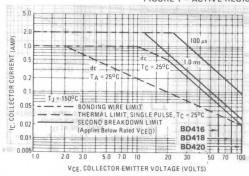


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	ь	ú	ú	i

Charact	eristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	(deuninos) (U) 1	SINSTOAMANU JAON	44.1		
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BVCEO	MIAE 60	2008 2 - 20 CH		
	BD418 BD420		100	S - LT   H   T	
Collector-Base Breakdown Voltage (IC = 100 µAdc, IE = 0)	01 - 8 BD416 38V	BVCBO	60		Vdc
	BD418 BD420		100		
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)	111111111111111111111111111111111111111	BVEBO	5.0	0 3 - 1 -	Vdc
Collector Cutoff Current (VCB = 40 Vdc, IE = 0) (VCB = 60 Vdc, IE = 0)	BD416 BD418	ICBO		100 100 100	nAdc
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)  Emitter Cutoff Current  (V <sub>EB</sub> = 4.0 Vdc, I <sub>C</sub> = 0)	BD420	1EBO		100	nAdc
ON CHARACTERISTICS (1)	20 20 58 10	0007 203 205	1001 0.1	K 81 0.4 1	0.5
(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	raat – e arkudia	WOIDE	60 80 60 25	300	FIGURE
Collector Emitter Saturation Voltage (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 1,0 Adc, I <sub>B</sub> = 100 mAdc)	(381-32) <sub>A</sub> inj 3A <sub>10</sub> , 92'0	VCE(sat)		0.5 1.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)	Applied to	V <sub>BE</sub> (on)	11-11-11	1.2	Vdc
DYNAMIC CHARACTERISTICS		8 II A	1 / Am 000 Am 00	52 Am D	i ngi
Current-Gain — Bandwidth Product (IC = 100 mAdc, VCE = 5.0 Vdc, f	= 20 MHz)	₹ fr	75	350	MHz
Collector-Base Capacitance (VCB = 20 Vdc, IE = 0, f = 1.0 MF	150 - 150 + 02 L	C <sub>cb</sub>		18	pF

#### TYPICAL CHARACTERISTICS

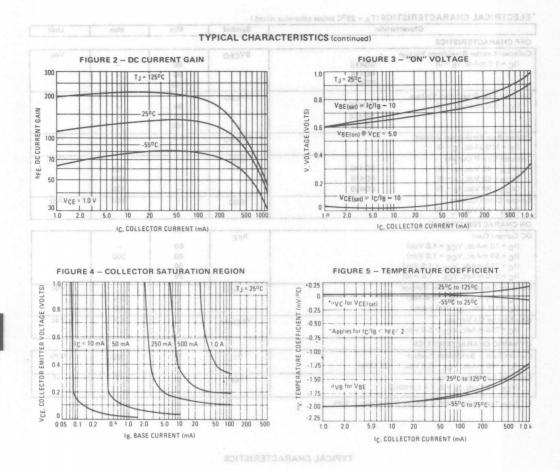
FIGURE 1 - ACTIVE REGION SAFE OPERATING AREA

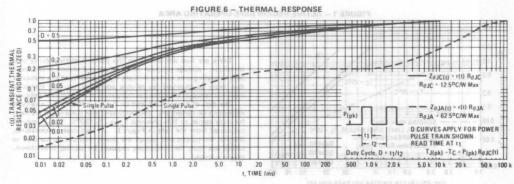


(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

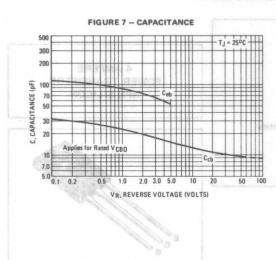
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

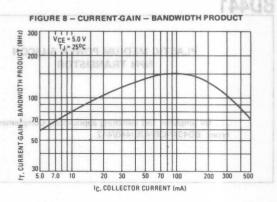
The data of Figure 1 is based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$  provided  $T_{J(pk)} \le 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).





### TYPICAL CHARACTERISTICS (continued)





SOMITA: MUMINAS

		iype	outsV	
Collector Emisser Voltage	Усво	80433 80437 80437 80438 80438		
	OSD <sup>V</sup>	8D433 8D435 8D435 8D435 8D441		
Emitter Brac Voltage				
Base Current				
Total Device Chargarton TC = 25th Device ab. a 25°C	d <sub>d</sub>			
Operating and Storage Junction Temperature range.				

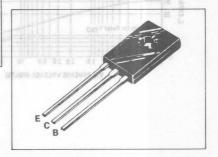
THERMAL CHARACTERISTICS

	Nax.	Symbol	
			Thermal Resistance Junction to Case

#### PLASTIC MEDIUM POWER SILICON NPN TRANSISTOR

. . . for amplifier and switching applications Complementary types: BD434/436/438/440/442

4 AMPERE
POWER TRANSISTOR
NPN SILICON



#### **MAXIMUM RATINGS**

Rating	Symbol	Туре	Value	Unit
Collector Emitter Voltage	V <sub>CEO</sub>	BD433	22	Vdc
	020	BD435	32	
		BD437	45	
		BD439	60	
		BD441	80	
Collector Base Voltage	V <sub>CBO</sub>	BD433	22	Vdc
	000	BD435	32	
		BD437	45	
		BD439	60	
		BD441	80	
Emitter Base Voltage	VEBO		5	Vdc
Collector current	1c		4	Adc
Base Current	IB		1	Adc
Total Device Dissipation T <sub>C</sub> = 25°C Derate above 25°C	PD		36 288	Watts mW/°C
Operating and Storage Junction Temperature range.	IJ, I <sub>stg</sub>		-55 to +150	°C

# 7.74 3.68 3.75 4.01 2.92 DIA THRU 2.15 0.50 0.60 0.60 0.60 15.36 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.79 1.14 2.41 2.66

#### THERMAL CHARACTERISTICS

	Symbol	Max.	Unit
Thermal Resistance Junction to Case	θЈС	3.5	°C/W

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

**CASE 77-04** 

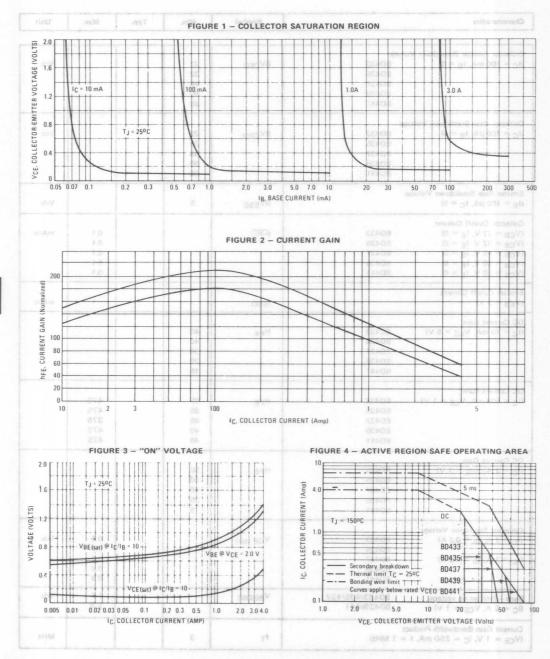
When mounting the device, torque not to exceed  $0.07\ m\text{-kg}$ 

3

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> - 25 °C unless otherwise noted)

Characteristics	NCIDER NOTARUTAS	Symbol	Min.	Тур.	Max.	Unit
	THE STATE OF STREET		THE DE		11	W 105 =
Collector Emitter Breakdown Vo	ltane		I I I I I I I I I I I I I I I I I I I			
	BD433	PV	22			Vdc
$(I_C = 100 \text{ mA}, I_B = 0)$		BVCEO			11	Vac
	BD435		32		11 115	1 3
Adl	BD437		45		Am Dit - no	1 6
	BD439		60			1-121 5
	BD441		80			
Collector Base Breakdown Volta	ge					38
$(I_C = 100  \mu A, I_B = 0)$	BD433	BVCBO	22	3785 - 17	ft 1137	Vdc
11C 100 MA, 18	BD435	PACRO.	32		11	Vac -
	BD437					100
			45			1 2
	BD439 BD441		60 80		1	11 6
	80441		00	1.0		10 3
Emitter Base Breakdown Voltage	to a fattitude	1247.01	10. (0.0)	3.00		50.0
$(I_E = 100  \mu A, I_C = 0)$		BVEBO	5			Vdc
Collector Cutoff Current						
(V <sub>CB</sub> = 22 V, I <sub>E</sub> = 0)	BD433	ICBO			0.1	mAdc
	BD435	PIGURE 2 - CU			0.1	IIIAGC
$(V_{CB} = 32 \text{ V}, I_{E} = 0)$	00433				1	1.
$(V_{CB} = 45 \text{ V}, I_{E} = 0)$	BD437				0.1	
$(V_{CB} = 60 \text{ V}, I_{E} = 0)$	BD439				0.1	11
$(V_{CB} = 80 \text{ V}, I_{E} = 0)$	BD441				0.1	.00%
Emitter Cutoff Current						- Control
(V <sub>EB</sub> = 5 V)		IEBO			1	mAdc
			++++		7	1
DC Current Gain						1 5
$(I_C = 10 \text{ mA}, V_{CE} = 5 \text{ V})$	BD433	HFE	40			201 2
	BD435		40			The same
	BD437		30	-	-	08 2
	BD439		20			- m 5
	BD441		15			100 2
						20
DC Current Gain						The second
$(I_C = 500 \text{ mA}, V_{CE} = 1 \text{ V})$	BD433	HFE	85		475	0
	BD435	0	85		475	or -
	BD437	OD ROTTSLIED OF	85		375	
	BD439		40		475	
	BD441		40		475	1
DC Current Gain	UN STANSON UNION		3067309	-NO 6	ALIGNIA .	
(I <sub>C</sub> = 2 A, V <sub>CE</sub> = 1 V)	BD433	HFE	50	H HIELL	111111	2.8 [ ]
TO TO THE TOTAL	BD435		50	4 4144	1 104 1 -4	
		1 1 1 1 1 1		I HITL	T3 - 28°C	1. 1.
	BD437		40	it with		1-1-1
	BD439		25	11 11 11 1		
1 00 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	BD441		15			
Collector Saturation Voltage		I Now I		1 1111		
(I <sub>C</sub> = 2 A, I <sub>B</sub> = 0.2 A)	BD433	VCE (sat)			0.5	Vdc
A Little	BD435	CE (291)	HOST	10 01 - 01	0.5	1 100
$(I_C = 3 \text{ A}, I_B = 0.3 \text{ A})$	BD437	A 0 2 - 32A 8 3		White was been to the Control	0.7	
TEAUN TEAUN	BD437	THE PERSON NAMED IN			0.7	
DEADS OFF	BD439 BD441	N	111111		0.8	110
THE THEORY WAS ALSO WAS	VIII-00 TVOIN 600100	HIND	-	110037	1	1
Base – Emitter on voltage	BD433/435/437	VBE(ON)		T WITH	1.1	Vdc
$I_C = 2 A$ , $V_{CE} = 1 V$	BD439/441	.0 20 3040	20 69 53	1.0 20.0	1.5	0 -100.0
Current Gain Bandwidth D 1	тиалией дди	1	CHRON L (MORE)	70 RUTUS 1 10.	2	1
Current Gain Bandwidth Produc VCE = 1 V, IC = 250 mA, f		fT	3			MHz





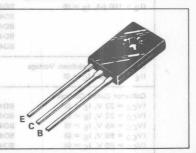


PLASTIC MEDIUM POWER SILICON PNP TRANSISTOR

... for amplifier and switching applications Complementary types: BD433/435/437/439/441.

4 AMPERE POWER TRANSISTOR PNP SILICON

**BD442** 

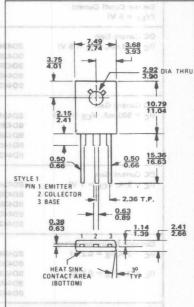


MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector Emitter Voltage	VCEO	BD434 BD436	22 32	Vdc
	95	BD438	45	
	30	BD440	60	
	20	BD442	80	
Collector Base Voltage	VCBO	BD434	22	Vdc
		BD436	32	
	85	BD438	45	
	88	BD440	60	
375	85	BD442	80	
Emitter Base Voltage	VEBO		5	Vdc
Collector current	1c		4	Adc
Base Current	01B	83	1	Adc
Total Device Dissipation	PD			Watts
$T_C = 25^{\circ}C$	28		36	mW/°C
Derate above 25°C	81		288	
Operating and Storage			FF 45 1 150	°C
Junction Temperature range.	lj, l <sub>stg</sub>		-55 to +150	-6

THERMAL CHARACTERISTICS

	Symbol	Max.	Unit
Thermal Resistance Junction to Case	θις	3.5	°C/W



When mounting the device, torque not to exceed 0.07 m-kg

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

All dimensions in millimeters

**CASE 77-04** 

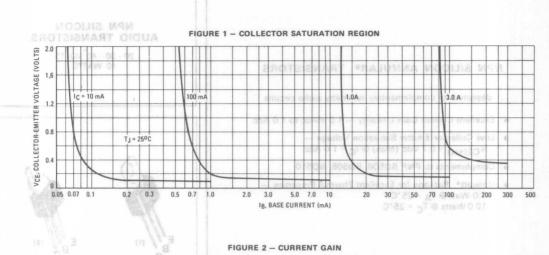
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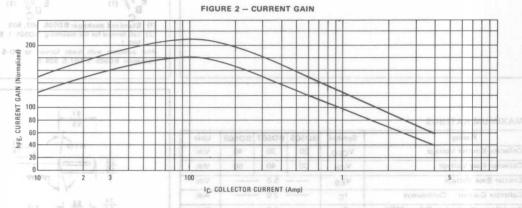
# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> - 25 °C unless otherwise noted)

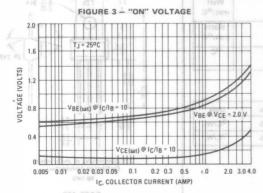
Characteristics				Symbol	Min.	Тур.	Max.	Unit
Collector Emitter Breakdown Volt (I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)	BD434 BD436 BD438 BD440 BD442				22 32 45 60 80	ASTIC MEE	19	Vdc
Collector Base Breakdown Voltage (IC = 100 $\mu$ A, IB = 0)	BD434 BD436 BD438 BD440 BD442		WENZOTY.	BV <sub>CBO</sub>		philips and wa		Vdc
Emitter Base Breakdown Voltage (I $_{\rm E}=100~\mu{\rm A},~{\rm I}_{\rm C}=0)$				BVEBO	5			Vdc
Collector Cutoff Current (V <sub>CB</sub> = 22 V, I <sub>E</sub> = 0) (V <sub>CB</sub> = 32 V, I <sub>E</sub> = 0) (V <sub>CB</sub> = 45 V, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 V, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 V, I <sub>E</sub> = 0)	BD434 BD436 BD438 BD440 BD442			ICBO			0.1 0.1 0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 5 V)		tinti	suinV	I <sub>EBO</sub>	latinyê		1	mAdc
DC Current Gain (I <sub>C</sub> = 10 mA, V <sub>CE</sub> = 5 V)	BD434 BD436 BD438 BD440 BD442	Vac	92 32 45 60 80	HFERNOR BEAGS GEAGS GEAGS SANGS	40 40 30 20	901	Emircer Vols	Collecto
DC Current Gain (I <sub>C</sub> = 500 mA, V <sub>CE</sub> = 1 V)	BD434 BD436 BD438 BD440 BD442	SEV	32 45 60 80 8	HEEST SANGE	85 85 85 40 40		475 475 375 475 475	iorselleC
DC Current Gain (I <sub>C</sub> = 2 A, V <sub>CE</sub> = 1 V)	BD434 BD436 BD438 BD440 BD442	Adc Watts mW/PC	30 885	H <sub>FE</sub>	50 50 40 25 15	n	olor Dissipatio	
Collector Saturation Voltage (I <sub>C</sub> = 2 A, I <sub>B</sub> = 0.2 A) (I <sub>C</sub> = 3 A, I <sub>B</sub> = 0.3 A)	BD434 BD436 BD438 BD440 BD442	3*	0814 ar	VCE (sat)	nt I of	.06.90.	0.5 0.5 0.7 0.8 0.8	Vdc
Base – Emitter on voltage (I <sub>C</sub> = 2 A, V <sub>CE</sub> = 1 V)		436/438 442		V <sub>BE</sub> (ON)			1.1 1.5	Vdc
Current Gain Bandwidth Product (VCE = 1 V, IC = 250 mA, f =	1 MHz)			fT	3	renistics	CHARAC	MHz

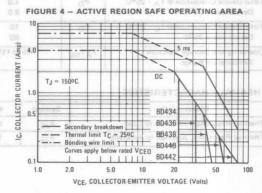
MOTOROLA











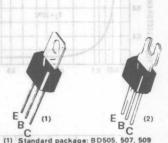
#### NPN SILICON ANNULAR\* TRANSISTORS

designed for complementary symmetry audio circuits

- Excellent Current Gain Linearity 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.7 Vdc (Max) @ I<sub>C</sub> = 1.0 Adc
- Complements to PNP BD506, BD508, BD510
- Uniwatt<sup>A</sup> Package for Excellent Thermal Properties
   1.0 Watt @ T<sub>A</sub> = 25 °C
   10.0 Watts @ T<sub>C</sub> = 25 °C

#### NPN SILICON AUDIO TRANSISTORS

20 - 30 - 40 VOLTS 10 WATTS



(1) Standard package: BD505, 507, 509
(2) Tab formed for flat mounting BD505-1, 507-1, 509-1

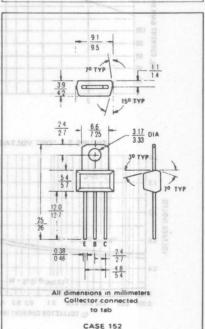
Also available with leads formed to TO-5 configuration BD505-5, 507-5, 509-5

#### MAXIMUM RATINGS

Rating	Symbol	BD505	BD507	BD509	Unit
Collector-Emitter Voltage	VCEO	20	30	40	Vdc
Collector-Base Voltage	VCB	30	40	50	Vdc
Emitter-Base Voltage	VEB	1 -	- 5.0 -		Vdc
Collector Current Continuous	1c	10000	- 2.0 -		Adc
Total Device Dissipation @ T <sub>A</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	P <sub>D</sub>	anuo)	1.0		Watt mW/ <sup>O</sup> C
Total Device Dissipation @ T <sub>C</sub> - 25°C  Derate above 25°C	PD		10 80		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	- 4	55 to +15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	125	°C/W
Thermal Resistance, Junction to Ambient	θЈА	125	°C/W



3

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

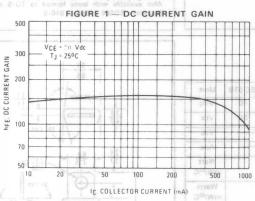
Characteristic		Symbol	Min	Тур	Max	Unit
FF CHARACTERISTICS	-					Taylor e
Collector-Emitter Breakdown Voltage	BD505	BVCEO	20	_		Vdc
(I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD507	020	30		- 1	
PNP SILICON	BD509		40	_	_	
Emitter-Base Breakdown Voltage $(I_E = 100 \mu Adc, I_C = 0)$		BVEBO	5	_	-	Vdc
Collector Cutoff Current	BD505 BD507	СТ СВО	ULAH®	MMATMOS	100	nAdo
(VCB = 20, 30, 40 Vdc, I <sub>E</sub> = 0)	BD507			_	100	

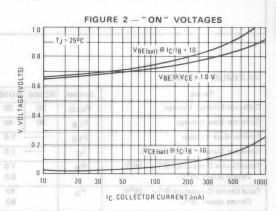
#### ON CHARACTERISTICS

DC Current Gain (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 2 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2 Vdc)	0. mAda to 1.0 Adc nage 1.0 Adc	60 40 3	160	Excellent C Low-Collet VCE(sat)	. –
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	VCE(sat)		0.30	Compleme	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	V <sub>BE(on)</sub>	- 0	0.91	1.2 0sW 0.01	Vdc

SMALL-SIGNAL CHARACTERISTICS					
Current-GainBandwidth Product (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)	fT	50	250	_	MHz
Output Capacitance (V <sub>CR</sub> = 10 Vdc, I <sub>F</sub> = 0, f = 100 kHz)	C <sub>ob</sub>	_	_	30	pF

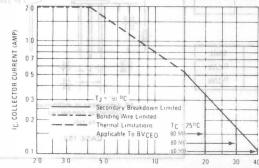
(1) Pulse Test Pulse Width 5 300 µs. Duty Cycle 5 20%





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#### FIGURE 3 - DC SAFE OPERATING AREA

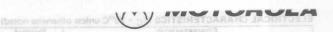


VCE. COLLECTOR EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub> -V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Temperature Range

The data of Figure 3 is based on  $T_{J(pk)} = 150$  °C;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



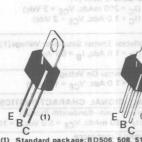
#### PNP SILICON ANNULAR+ TRANSISTORS

designed for complementary symmetry audio circuits

- Excellent Current Gain Linearity 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage —
   V<sub>CE(sat)</sub> = 0.7 Vdc (Max) @ I<sub>C</sub> = 1.0 Adc
- Complements to NPN BD505, BD507, BD509
- Uniwatt<sup>♠</sup> Package for Excellent Thermal Properties —
   1.0 Watt @ T<sub>A</sub> = 25 °C
   10.0 Watts @ T<sub>C</sub> = 25 °C

#### PNP SILICON AUDIO TRANSISTORS

20 - 30 - 40 VOLTS



(1) Standard package: BD506, 508, 510 (2) Tab formed for flat mounting: BD506-1, 508-1, 510-1

Also available with leads formed to TO-5 configuration: BD506-5, 508-5, 510-5

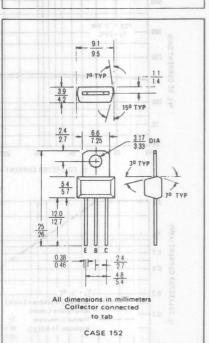
#### MAXIMUM RATINGS

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Rating	Symbol	BD506	BD508	BD510	Unit
Collector-Emitter Voltage	VCEO	20	30	40	Vdq
Collector-Base Voltage	VCB	30	40	50	Vdc
Emitter-Base Voltage	VEB	1	5.0		
Collector Current Continuous	1c	2.0			Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0			Watt mW/ <sup>o</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	OMETAS S	55 to +15	08 30	°°C

#### THERMAL CHARACTERISTICS

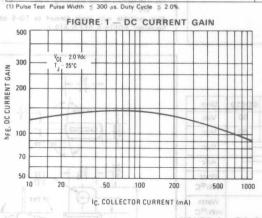
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	12.5	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	125	°C/W

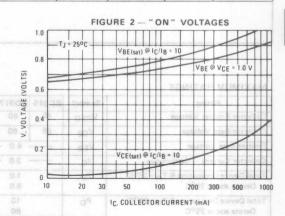


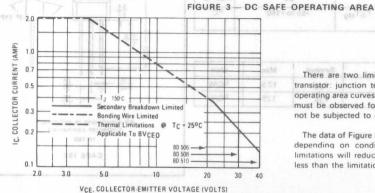
3-408

#### BD506, BD508, BD510

ELECTRICAL CHARACTERISTICS (TC = 2	50C unless o	therwise noted)		19	805	0517
Characteristic	o o amess o	Symbol	Min	Тур	Max	Unit
FF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD506 BD508 BD510	BACEO	20 30 40	=	=	Vdc
Emitter-Base Breakdown Voltage $(I_E = 100 \mu Adc, I_C = 0)$		BVEBO	5.0	_	_	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 20, 30, 40 Vdc, I <sub>E</sub> = 0)	BD506 BD508 BD510	СВО	N ANNU TRANSIS	PN STLICO	100 100 100	nAdc
N CHARACTERISTICS	toynb br	age amplifier an	ie, high-veh	eneral purpo	igned for g	asb des
DC Current Gain (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.0 Vdc)		h <sub>FE</sub> — ag	60 40	135	Collector	• High
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)		VCE(sat)	bam <u>1 = 3</u> 1	0.40 bV	08 0.7	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)		V <sub>BE(on)</sub>	518, BD52	0.92		
MALL-SIGNAL CHARACTERISTICS						THEFE
Current-Gain-Bandwidth Product (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)		f <sub>T</sub>	50	180	_	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)		Cob	-	_	30	pF







There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C = V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on TJ (pk) =  $150\,^{\circ}$ C; TC is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



# NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

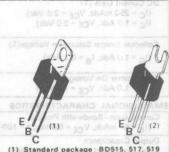
30

... designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage —
   BV<sub>CEO</sub> = 45 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD515 60 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD517 80 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD519
- High Power Dissipation  $P_D = 10 \text{ W} @ T_C = 25 ^{\circ}\text{C}$
- Complements to BD516, BD518, BD520

NPN SILICON AMPLIFIER TRANSISTORS

> 45 - 60 - 80 VOLTS 10 WATTS



(1) Standard package: BD515, 517, 519
 (2) Tab formed for flat mounting. BD515-1, 517-1, 519-1

Also available with leads formed to TO-5 configuration: BD515-5, 517-5, 519-5

#### MAXIMUM RATINGS

Rating	Symbol	BD515	BD517	BD519	Unit
Collector-Emitter Voltage	VCEO	45	60	80	Vdc
Collector-Base Voltage	VCB	45	60	80	Vdc
Emitter-Base Voltage	VEB	102	4.0 -		Vdc
Collector Current - Continuous	1c	-	- 2.0 -	<del>H</del> T	Adc
Total Device Dissipation @ T <sub>A</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	DI 0	1.0	1111 9001	Watt mW/ <sup>O</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		10 80		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-!	55 to +15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	12.5	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	125	°C/W

(\$110A) 399110A)

not be subjected to greater discipation than the curves indical.

The data of Fourier 3 is based on Libbar = 150 °C. To it visible

mations will reduce the power that can be handled to visions the limitations imposed by sepondary breakdown.

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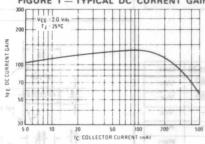
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#### ELECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD515 BD517 BD519	BVCEO	45 60 80	=		Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)		BVEBO	4.0	- NO LIES BUG		Vdc
Collector Cutoff Current ( $V_{CB} = 30 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 40 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 60 \text{ Vdc}$ , $I_E = 0$ )	BD515 BD517 BD519	СВО	TRANSIS	MPLIFIER oneral-purpor	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) ( $I_C = 10 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$ ) ( $I_C = 150 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$ ) ( $I_C = 500 \text{ mAdc}, V_{CE} = 2.0 \text{ Vdc}$ )		80516	60 25	115 125 125 125	350	giH e
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 25 mAdc)		V <sub>CE(sat)</sub>		0.18 0.24		Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2.0 Vdc)		V <sub>BE(on)</sub>	BLOOR VIS	0.74	1.0	Vdc
MALL-SIGNAL CHARACTERISTICS						
Current-Gain-Bandwidth Product (IC = 200 mAdc, VCE = 5.0 Vdc, f = 100 MHz	)	f <sub>T</sub>	50	160		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)		Cop	-	6.0	12	pF

(1) Pulse Test Pulse Width ≤ 300 µs, Duty Cycle ≤ 20%

#### FIGURE 1 - TYPICAL DC CURRENT GAIN



#### FIGURE 2 - "SATURATION" AND "ON" VOLTAGES

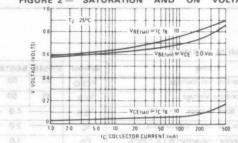
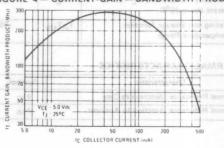


FIGURE 3 - DC SAFE OPERATING AREA



#### FIGURE 4 - CURRENT-GAIN - BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C\!-\!V_{CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on TJ (pk) = 150 °C: TC is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

# 3

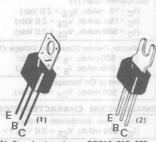
## PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

... designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage —
   BV CEO = 45 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD516 60 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD518 80 Vdc (Min) @ I<sub>C</sub> = 1 mAdc BD520
- High Power Dissipation P<sub>D</sub> = 10 W @ T<sub>C</sub> = 25 °C
- Complements to BD515, BD517, BD519

# PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

45 - 60 - 80 VOLTS



(1) Standard package: BD516, 518, 520(2) Tab formed for flat mounting BD516-1, 518-1, 520-1

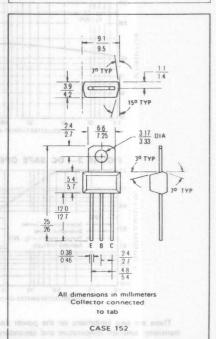
Also available with leads formed to TO-5 configuration BD516-5, 518-5, 520-5

#### MAXIMUM RATINGS

Rating	Symbol	PD516	BD518	BD520	Unit
Collector-Emitter Voltage	VCEO	45	60	80	Vdc
Collector-Base Voltage	VCB	45	60	80	Vdc
Emitter-Base Voltage	VEB	1	4.0 -		Vdc
Collector Current - Continuous	IC.	- 10 0.0	2.0 -	967	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD		1.0 8.0		Watt mW/ <sup>O</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	98UOF10 A3R		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150		°C	

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	12.5	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	125	°C/W

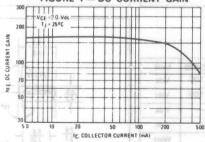


#### ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
FF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD516 BD518 BD520	BVCEO	45 60 80	=	=	Vdc
Emitter-Base Breakdown Voltage ( $I_E = 100 \mu Adc, I_C = 0$ )		BVEBO	4.0	-	-	Vdc
Collector Cutoff Current $(V_{CB} = 30 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 40 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 60 \text{ Vdc}, I_E = 0)$	BD516 BD518 BD520	I <sub>CBO</sub>	TRANSH as, high-vol	MPLIFIER	100 100 100	nAdc
N CHARACTERISTICS					tions.	olique
DC Current Gain (1)  (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 2.0 Vdc)  (I <sub>C</sub> = 150 mAdc, V <sub>CE</sub> = 2.0 Vdc)  (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2.0 Vdc)		97 - 97 - 97 - 97 - 97 - 97 - 97 - 97 -	60	150 130 80		p H o
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 25 mAdc)		VCE(sat)	10.1 = 51.93 1W 9T = 6	0.24 0.32	0.5	Vdc
Base-Emitter On Voltage (1) (IC - 500 mAdc, VCE 2 0 Vdc)		VBE(on)	8, H <u>H</u> B48, 1	0.78	1.0	Vdc
MALL-SIGNAL CHARACTERISTICS					-	
Current-GainBandwidth Product (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 M	Hz)	fT	50	125	_	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>F</sub> = 0, f = 100 kHz)		Cop	_	10	15	pF

(1) Pulse Test Pulse Width ≤ 300 µs, Duty Cycle' ≤ 2.0%.

#### FIGURE 1 - DC CURRENT GAIN



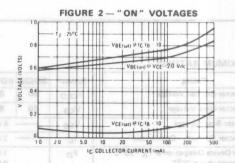


FIGURE 3 - DC SAFE OPERATING AREA

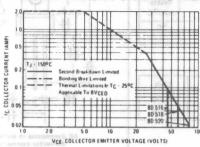
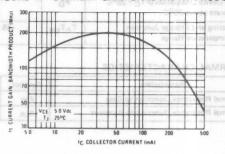


FIGURE 4 - CURRENT-GAIN-BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate

The data of Figure 3 is based on TJ (pk) = 150 °C; TC is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown

# NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

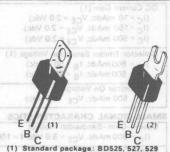
... designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage —
   BV<sub>CEO</sub> = 60 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD525
   80 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD527
   100 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD529
- High Power Dissipation P<sub>D</sub> = 10 W@ T<sub>C</sub> = 25°C
- Complements to PNP BD526, BD528, BD530

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# NPN SILICON

60 - 80 - 100 VOLTS 10 WATTS



(1) Standard package: BD525, 527, 529 (2) Tab formed for flat mounting: BD525-1, 527-1, 529-1

Also available with leads formed to TO-5 configuration: BD525-5, 527-5, 529-5

#### MAXIMUM RATINGS

Rating	Symbol	BD525	BD527	BD529	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB		4.0 -		Vdc
Collector Current - Continuous	lc .	0.0	2.0 -	407	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1.0			Watt mW/ <sup>O</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	10		Watts mW/OC	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	1000	-55 to +150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	12.5	°C/W
Thermal Resistance, Junction to Ambient	θЈА	125	°C/W

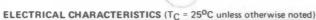
The data of Figure 3 is based on Ty  $\{g_k\}$  =  $150^{\circ}$ C, T<sub>C</sub> is variable depending on conditions. At high case temporarures, thormal limitations will reduce the power that can be hardled to values

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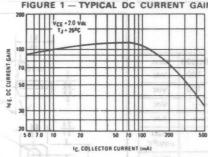
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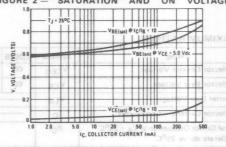


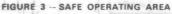
Characteristic		Symbol	Min	Тур	Max	Unit
Characteristic		Symbol	IVIIII	ТУР	IVIGA	Oint
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage	BD525	BVCEO	60	-	_	Vdc
(I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD527 BD529		100	_	_	
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)		BVEBO	има ис	NP SILIC	_	Vdc
Collector Cutoff Current		CNUTC	10 PLIMITE	721 112 11011		nAdc
(V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	BD525	СВО	_	_	100	
$(V_{CB} = 60 \text{ Vdc}, I_{E} = 0)$	BD527	shage amplified	oso, harmony	gener <del>al-</del> purp		
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	BD529			_	100	apple
ON CHARACTERISTICS						
DC Current Gain (1)		tage — tage	andown Vo	r-Emitter Bre	th Collection	H 9
(I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 2.0 Vdc)		GZGGBLE SPAU	60	115	" SHOV	
(I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 2.0 Vdc)		nAdc — BD526 mAdc — BD536	30	(miM) 95 bV 00		
Collector-Emitter Saturation Voltage(1)		VCE(sat)	Ps = 10 W	0.18	0.5	Vdc
(I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc)			_			
(I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)		BD529	25, 8 <del>5</del> 527	0.11/10/	mol <sub>em</sub> ients	9 C
Base-Emitter On Voltage (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)		V <sub>BE(on)</sub>	_	0.74	1.0	Vdc
MALL-SIGNAL CHARACTERISTICS						
Current-GainBandwidth Product (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100	MHz)	fT	50	150	_	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)		Cop	-	6.0	12	pF

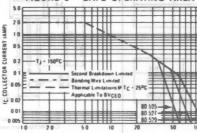
#### FIGURE 1 - TYPICAL DC CURRENT GAIN







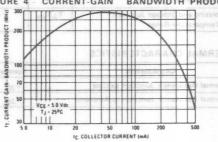




VCE. COLLECTOR EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $^1\mathrm{C}-^V\mathrm{CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate

FIGURE 4 CURRENT-GAIN BANDWIDTH PRODUCT



The data of Figure 3 is based on TJ(pk) = 150 °C; TC is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



## PNP SILICON ANNULAR\* AMPLIFIER TRANSISTORS

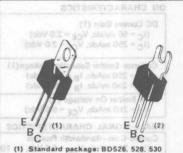
... designed for general-purpose, high-voltage amplifier and driver applications.

20308

- High Collector-Emitter Breakdown Voltage —
   BVCEO = 60 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD526 80 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD528 100 Vdc (Min) @ I<sub>C</sub> = 1.0 mAdc BD530
- High Power Dissipation P<sub>D</sub> = 10 W @ T<sub>C</sub> = 25°C
  - Complements to NPN BD525, BD527, BD529

# PNP SILICON AMPLIFIER TRANSISTORS

60 - 80 - 100 VOLTS 10 WATTS



(1) Standard package: BD526, 528, 530(2) Tab formed for flat mounting BD526-1, 528-1, 530-1

Also available with leads formed to TO-5 configuration BD526-5, 528-5, 530-5

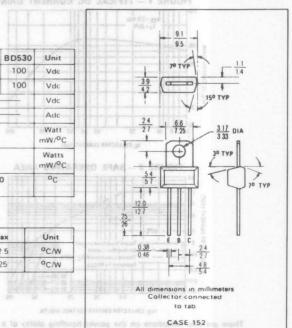
#### MAXIMUM RATINGS

3

Rating	Symbol	BD526	BD528	BD530	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter Base Voltage	VEB	- 53	- 40 -	7	Vdc
Collector Current Continuous	1c	h —	- 20 -	++-1	Adc
Total Device Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	8.1	1.0	000	Watt mW/ <sup>O</sup> C
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	6 amus	10	АЗЯ	Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	1 1	55 to +15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	12.5	°C/W
Thermal Resistance, Junction to Ambient	θΔΑ	125	°C/W



translator, punction temporature and secon key breakdown Safe

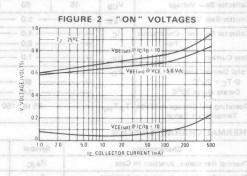
3-416

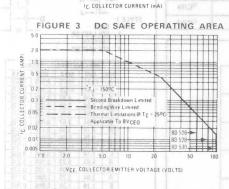
#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

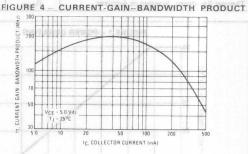
Characteristic			Symbol	Min	Тур	Max	Unit	
OFF CHARACTERISTICS						00	INU	GUU
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BD5 BD5 BD5	28		BVCEO	60 80 100	=	=	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)			3	BVEBO	00 4.0 c Y	EMENTAL POWSRI	COMP	Vdc
Collector Cutoff Current ( $V_{CB} = 40 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 60 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 80 \text{ Vdc}$ , $I_E = 0$ )	BD5 BD5	28	bns	ICBO		ter Sat <u>ur</u> ation		nAdc
N CHARACTERISTICS					38W 67 - 3	i for (XSIVI) Did v	en - Hon	2.4
DC Current Gain (1) (1 <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 2.0 Vdc) (1 <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 2.0 Vdc)				HPEQUE BE BOSSE BE BOSSE BESSE	60	153 98	VCEO (sus	-
Collector-Emitter Saturation Voltage(1) (1 <sub>C</sub> = 250 mAdc, 1 <sub>B</sub> = 10 mAdc) (1 <sub>C</sub> = 250 mAdc, 1 <sub>B</sub> = 25 mAdc)			\	CE(sat)	eth Product = 250 mAde	0.22 0.15	0.5	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)		×	TTUE	BE(on)	bie erdered	0.78	1.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Vdc
MALL-SIGNAL CHARACTERISTICS			-	-				
Current-GainBandwidth Product (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)		122	08	fr   asage	50	100	SEVILTAR	MHz
Output Capacitance (V <sub>CR</sub> = 10 Vdc, I <sub>F</sub> = 0, f = 100 kHz)	tin <b>U</b>	358	28	Cob	9063 <u>6</u>	100 100 M	15 gm3	pF

(1) Pulse Test Pulse Width ≤ 300 µs, Duty Cycle ≤ 20%.

# 







There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $I_{\rm C} = V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on  $T_{J}(pk) = 150$  °C:  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



#### COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

abAn. . . designed for use in general purpose amplifier and switching applications.

- Collector-Emitter Saturation Voltage -VCE = 0.8 Vdc (Max) @ IC = 2.0 Adc
- Collector-Emitter Sustaining Voltage —

VCEO (sus) = 45 Vdc (Min) BD533, BD534

= 60 Vdc (Min) BD535, BD536

= 80 Vdc (Min) BD537, BD538

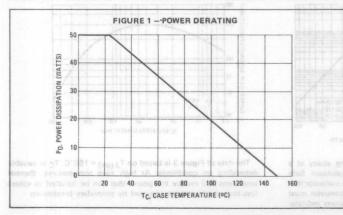
- High Current Gain Bandwidth Product fT = 3.0 MHz (Min) @ IC = 250 mAdc
- Compact TO-220 AB Package
- TO-66 Leadform Also Available ordered with "-66" suffix

#### MAXIMUM RATINGS

Rating 2	Symbol	BD533 BD534	BD535 BD536	BD537 BD538	Unit
Collector-Emitter Voltage	VCEO	45	60	80	Vdc
Collector-Base Voltage	VCB	45	60	80	Vdc
Emitter-Base Voltage	VEB	neune:	5.0	- 1/	Vdc
Collector Current - Continuous Peak	lc l	I be d	4.0 8.0		Adc
Base Current	IB		1.0	-	Adc
Total Device Dissipation  © T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD		50 0.4		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		°C		

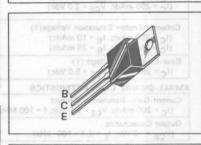
#### THERMAL CHARACTERISTICS

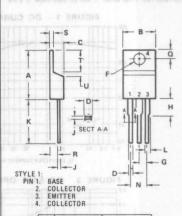
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	2.5	°C/W
Thermal Resistance, Junction to Ambient	ReJA	70	°C/W



#### 4 AMPERED - MAY POWER TRANSISTORS COMPLEMENTARY SILICON

45, 60, 80 VOLTS 50 WATTS





DIM	MILLIMETERS		INCHES		
	MIN	MAX	MIN	MAX	
A	15.11	15.75	0.595	0.620	
В	9.65	10.29	0.380	0.405	
C	4.06	4.82	0.160	0.190	
D	0.64	0.89	0.025	0.035	
F	3.61	3.73	0.142	0.147	
G	2.41	2.67	0.095	0.105	
Н	2.79	3.30	0.110	0.130	
J	0.36	0.56	0.014	0.022	
K	12.70	14.27	0.500	0.562	
L	1.14	1.27	0.045	0.050	
N	4.83	5.33	0.190	0.210	
0	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	
T	5.97	6.48	0.235	0.255	
U	0.76	1.27	0.030	0.050	

MHz

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted)

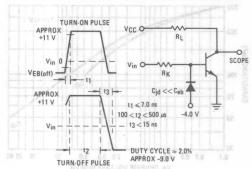
Characteristic	Symbol	Min.	Max.	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage <sup>1</sup> (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0)	BD533, BD534	VCEO(sus)	45		Vdc
	BD535, BD536		60		
	BD537, BD538		80		Dean
Collector Cutoff Current	Ісво			mAdc	
(V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0)	BD533, BD534			0.1	0.2
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	BD535, BD536			0.1	1
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	BD537, BD538			0.1	
Collector Cutoff Current		ICES			μAdc
(V <sub>CE</sub> = 45 Vdc, V <sub>EB</sub> = 0)	BD533, BD534		1	100	0.00
(VCE = 60 Vdc, VEB = 0)	BD535, BD536			100	10.00 ED.0
(VCE = 80 Vdc, VEB = 0)	BD537, BD538			100	Tables Chill
Emitter Cutoff Current	IEBO	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	LUM BLOWIS -	mAdc	
(V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)				1.0	0.00
ON CHARACTERISTICS1			3.7 1.0		
DC Current Gain		hFE		T	
(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 5 Vdc)	BD533, BD534		20		
	BD535, BD536	STATES OF STREET	20		
	BD537, BD538	37113N - 03	15		
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2 Vdc)		40		- 1	
(IC = 2 Adc, VCE = 2 Vdc)	BD533, BD534		25		
	BD535, BD536		25		10.0
limitations on the power handling softing	BD537, BD538	10,001	0.1 15		
Collector-Emitter Saturation Voltage	VCE(sat)		Y JANA SS	Vdc	
(I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 0.2 Adc)		1/1	0.8	100	
		VBE(on)			Vdc
Base-Emitter On Voltage					

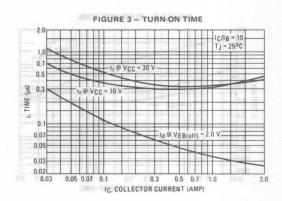
<sup>&</sup>lt;sup>1</sup> Pulse test = Pulse width ≤300  $\mu$ s, Duty Cycle ≤2.0%.

( $I_C = 250 \text{ mAdc}$ ,  $V_{CE} = 1 \text{ Vdc}$ ,  $f_{test} = 1 \text{ MHz}$ )

Current Gain - Bandwidth Product<sup>2</sup>

#### FIGURE 2 - SWITCHING TIME EQUIVALENT CIRCUIT



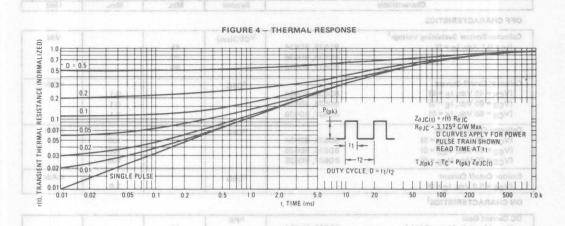


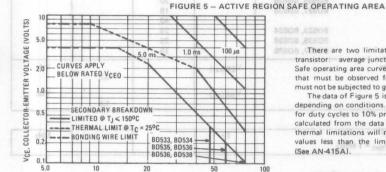
3.0

IC, COLLECTOR CURRENT (AMP)

<sup>2</sup> fT = |hfe| · ftest







IC, COLLECTOR CURRENT (AMP)

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown.

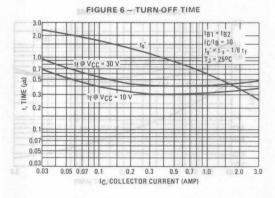
(fg = 500 māde, Vgg = 2 Vde)

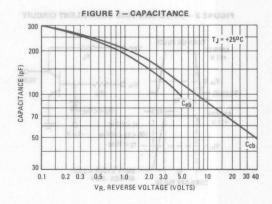
Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 5 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to

values less than the limitations imposed by second breakdown.

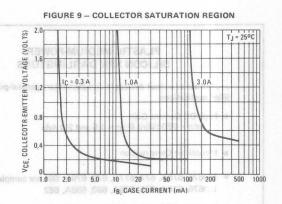
1 Pules test o Pulse width ≤300 ta; Duty Cycle ≤ 2.0%

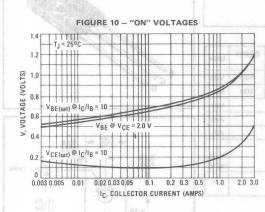
(See AN-415A).

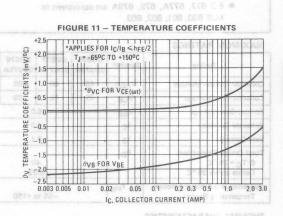


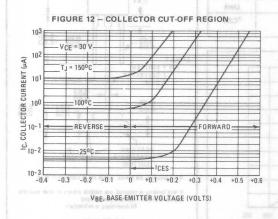


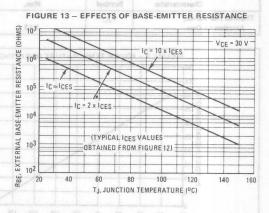
MOTOROLA













PLASTIC MEDIUM-POWER
SILICON NPN DARLINGTONS

... for use as output devices in complementary general-purpose amplifier applications.

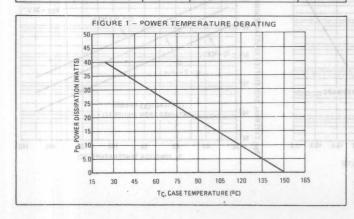
- High DC Current Gain –
   hFE = 750 (Min) @ I<sub>C</sub> = 1.5 and 2.0 Adc
- Monolithic Construction
- BD675, 675A, 677, 677A, 679, 679A, 681 are complementary with BD676, 676A, 678, 678A, 680, 680A, 682
- BD 677, 677A, 679, 679A are equivalent to MJE 800, 801, 802, 803

#### MAXIMUM RATINGS

Rating	Symbol	BD675 BD675A	BD677 BD677A	BD679 BD679A	BD681	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	100	Vdc
Emitter-Base Voltage	VEB	5.0				
Collector Current	1c			Adc		
Base Current	IB	0.1				Adc
Total Device Dissipation  © T <sub>C</sub> = 25 °C  Derate above 25 °C	PD	40 0.32				Watts W/°C
Operating and Storage Junction Temperating Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150			2.0 2.0	°C

### THERMAL CHARACTERISTICS

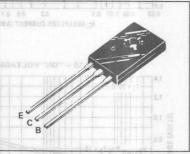
Characteristic	Symbol	Max.	Unit
Thermal Resistance,	θ <sub>JC</sub>	FIGURE 13	°C/W
Junction to Case		3.13	

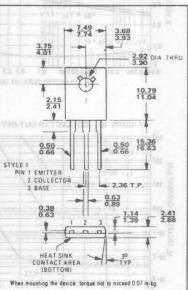


4.0 AMPERE
DARLINGTON
POWER TRANSISTORS
NPN SILICON

FIGURE 8 - DC CURRENT DAIN

45, 60, 80, 100 VOLTS 40 WATTS





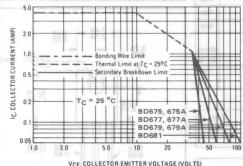
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend All dimensions in millimeters

CASE 77-04

## ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic			Max	Unit
BD675, 675A BD677, 677A BD679, 679A BD681	BVCEO	45 60 80 100	=	Vdc
ER	OBD! EDIUM-PON DARLING	ASTIC M	500	μAdc
general purpose amo-	<sup>1</sup> CBO	rdayl <u>c</u> es in	0.2 2.0	mAdc
	<sup>1</sup> EBO	- nist)	2.0 100 Current	mAdc
	IDA U.S. DITE D.	- Or action	181 50 1 3	44.
BD675, 677, 679, 681 BD 675A, 677A, 679A	pEE	750 750	hishic Const	nooM Te
BD 677, 679, 681 BD 675A, 677A, 679A	VCE (sat)	77, 677A, 6	2.5 2.8	Vdc
BD 677, 679, 681 BD 675A, 677A, 679A	VBE(on)	02, 703	2.5 2.5	Vdc
			Sent	AF MUM
79 SOSES SDESZ Units SA SDESSA	hfe A	1.0	- gai	tual -
	BD675, 675A BD677, 677A BD679, 679A BD681 BD675, 677, 679, 681 BD 675A, 677A, 679A BD 675A, 677A, 679A BD 675A, 677A, 679A	BD675, 675A BD679, 679A BD681  ICEO  ICEO  ICEO  IEBO  BD675, 677, 679, 681 BD 675A, 677A, 679A  BD 677, 679, 681 BD 675A, 677A, 679A  BD 677, 679, 681 BD 677, 679, 681 BD 677, 679, 681	BD675, 675A BD677, 677A BD679, 679A BD681	BD675, 675A BD677, 677A BD677, 679A BD675, 677, 679, 681 BD 675A, 677A, 679A BD 675A,

#### FIGURE 2 - DC SAFE OPERATING AREA

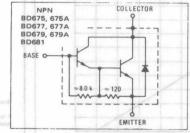


There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>=V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)





## PLASTIC MEDIUM-POWER SILICON PNP DARLINGTONS

... for use as output devices in complementary general-purpose amplifier applications.

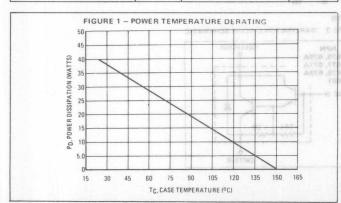
- High DC Current Gain —
   hfE = 750 (Min) @ IC = 1.5 and 2.0 Adc
- Monolithic Construction
- BD676, 676A, 678, 678A, 680, 680A, 682 are complementary with BD675, 675A, 677, 677A, 679, 679A, 681
- BD 678, 678A, 680, 680A are equivalent to MJE 700, 701, 702, 703

#### MAXIMUM RATING

Rating	Symbol	BD676 BD676A	BD678 BD678A	BD680 BD680A	BD682	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	100	Vdc
Emitter-Base Voltage	VEB	AB	- DC SA	Vdc		
Collector Current	1c		HH	Adc		
Base Current	IB	0.1				Adc
Total Device Dissipation  @ T <sub>C</sub> = 25 °C  Derate above 25 °C	P <sub>D</sub>	40 0.32				Watts W/°C
Operating and Storage Junction Temperating Range	T <sub>J</sub> , T <sub>stg</sub>					°C

## THERMAL CHARACTERISTICS

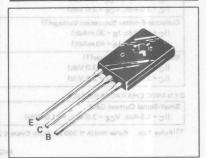
Characteristic	Symbol	Max.	Unit
Thermal Resistance,	θις		°C/W
Junction to Case		3.13	KENTE

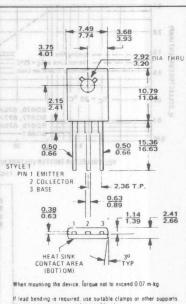


# 4.0 AMPERE DARLINGTON POWER TRANSISTORS PNP SILICON

45, 60, 80, 100 VOLTS 40 WATTS

(Vgg = 8and BVggo, tg = 0, Tg = 100°C)





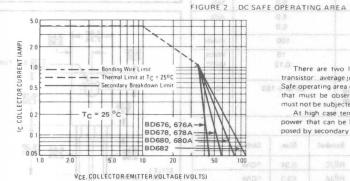
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend All dimensions in millimeters

CASE 77-04

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

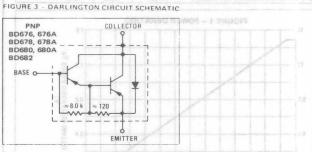
Characteristic			Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	BD676, 676A BD678, 678A BD680, 680A BD682	BVCEO	45 60 80 100	<del>-</del> -	Vdc
Collector Cutoff Current (V <sub>CE</sub> = Half Rated V <sub>CEO</sub> , I <sub>B</sub> = 0)	PLEMENTARY TRANSISTORS and high-meed	ICEO	ARLING VIVULAF senerāl pu	500	μAdc
Collector Cutoff Current (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0) (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0, T <sub>C</sub> = 100°C)	itters for desk calculators.	СВО		0.2 2.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO par			
ON CHARACTERISTICS		YOR - (nitil)			3.9
DC Current Gain(1) $(I_C = 1.5 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$ $(I_C = 2.0 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$		(Mingah BD)	56V 08 =	serse Voltag	- P Re
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 30 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 40 mAdc)	BD 678, 680, 682	VCE (sat)	utruction Construct	2.5 2.8	Vdc
Base-Emitter On Voltage(1) (IC = 1.5 Adc, VCE = 3.0 Vdc)	BD 678, 680, 682	VBE(on)	3	2.5	Vdc
(I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	BD 676A, 678A, 680A			2.5	
DYNAMIC CHARACTERISTICS	25 80277 80775 Unit	TOR ICOMYS		90)	127年
Small-Signal Current Gain (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 MHz)	98 V36	h <sub>fe</sub>	1.0	-	
11-	464 66 66	VCED 4	nGarro A	e171m3-10108	(4.3)

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)



CASE 27-04

## PLASTIC DARLINGTON COMPLEMENTARY SILICON ANNULARO POWER TRANSISTORS

. . . designed for general purpose amplifier and high-speed switching applications such as hammer drivers for desk calculators.

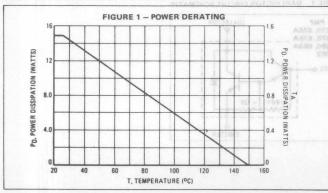
- · High DC Current Gain hFE = 1400 (Typ) @ IC = 2.0 Adc
- · Collector-Emitter Sustaining Voltage @ 10 mAdc VCEO (sus) = 45 Vdc (Min) - BD775, 776
  - = 60 Vdc (Min) BD777, 778
  - = 80 Vdc (Min) BD779, 780
- · Reverse Voltage Protection Diode
- · Monolithic Construction with Built-in Base-Emitter output Resistor
- Thermopad II<sup>△</sup> Construction with Hard Solder for High Reliability.

#### **MAXIMUM RATINGS**

	Rating	Symbol	BD775 BD776	BD777 BD778	BD779 BD780	Unit
	Collector-Emitter Voltage	VCEO	45	60	80	Vdc
	Collector-Base Voltage	VCB	45	60	80	Vdc
	Emitter-Base Voltage	VEB	TING ARE	5.0	BAS DO	Vdc
	Collector Current — Continuous Peak	1 <sub>C</sub>		4.0 6.0	H	Adc
	Base Current	1 <sub>B</sub>		100		mAdc
a to yai	Total Device Dissipation $T_C = 25^{\circ}C$ — Derate above $25^{\circ}C$	P <sub>D</sub>	15 0.12			Watts W/°C
ansister ensister ndicate.	junction Temperature	TJ, T <sub>stg</sub> TJ, T <sub>stg</sub>	- 65 to +150		°C	

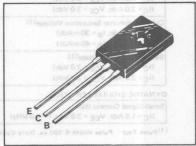
#### THERMAL CHARACTERISTICS

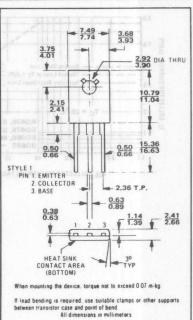
Characteristics	Symbol	Max.	Unit	加
Thermal Resistance, Junction to Case	RθJC	8.34	°C/W	08
Thermal Resistance, junction to Ambient	$R\theta$ JA	83.3	°C/W	



DARLINGTON 4-AMPERE COMPLEMENTARY SILICON **POWER TRANSISTORS** 45, 60, 80 VOLTS 15 WATTS

11g = 50 mAde, 1g = 01





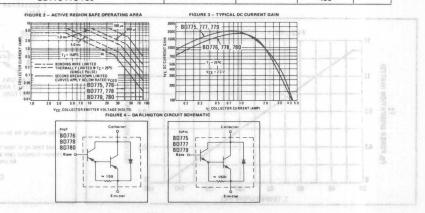
Annular Semiconductors Patented by Motorola Inc.

**CASE 77-04** 

Trademark of Motorola Inc.

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

CHARACTERISTIC	IARACTERISTIC		SYMBOL	MIN.		MAX.	UNIT
OFF CHARACTERISTICS							
Collector-Emitter Collector-Emitter Sustaining Voltage (1) (IO = 10 mAdc, IB = 0) BD775, BD776 BD777, BD778 BD779, BD780		V <sub>CEO</sub> (sus)	45 60 80			Vdc	
Collector Cutoff Current (V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) BD775, BD776 (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) BD777, BD776 (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) BD779, BD780	8 rigin		CEOSHOT	RANSIS	r Aa	100 100 100	
Collector Cutoff Current ( $V_{CB} = Rated$ , $V_{CEO}$ (sus), $I_E = 0$ ) ( $V_{CB} - Rated$ , $V_{CEO}$ (sus), $I_E = 0$ , $I_C = 100$	o °C)		ICBO SERVICE	608 — (niñ 608 — (niñ	(de (l	1.0	μAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)				width Proc C = 100 m/		SO MHz Vikin	μAdc
ON CHARACTERISTICS		0.6	Specified at II S	The Paris of the Land		Lesson Spa	- 26 4
DC Current Gain (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc)			H <sub>FE</sub>	750		and 4.0 Adc	2.0
Collector-Emitter Saturation Voltage ( $I_C = 1.5 \text{ Adc}, I_B = 6 \text{mAdc}$ )			VCE (Sat)			1.5	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 6 mAdc)		- CORP	V <sub>BE</sub> (Sat)			2.5 SOMITA	Vdc
Base-Emitter On Voltage (IC = 1.5 Adc, $V_{CE} = 3 \text{ Vdc}$ )	Unit bbV	9788	V <sub>BE</sub> (On)	Symbol VGB0		2.3 miles	Vdc
Output Diode Voltage Drop (I <sub>EC</sub> = 2.0 Adc)	Volc	08	VEC	Veso		2.0 egatic	Vdc
DYNAMIC CHARACTERISTICS	olsA		0.5	0)		t - Continuous	der Carro
Current Gain Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	ab.A		fΤ	20		Aug	MHz
at S	Watts W/°C 90		SYMBOL	69	130,92	TYP.	UNIT
Turn-On Time (I <sub>C</sub> = 250 mA/V <sub>CE</sub> = 2 V) BD775-777-779 BD776-778-780			ton	25	531.	250	ns Haci
Turn Off Time (I <sub>C</sub> = 250 mA, V <sub>CE</sub> = 2 V) BD775-777-77 BD776-778-78	9 W/3 <sup>6</sup>	40.	toff OLGR		Case	600 400	ns of the



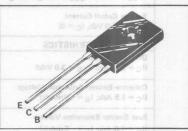


## COMPLEMENTARY PLASTIC SILICON ANNULAR® POWER TRANSISTORS

... designed for low power audio amplifier and low current, highspeed switching applications.

- Low Collector-Emitter Sustaining Voltage VCEO (sus) 45 Vdc (Min) - BD785, BD786 60 Vdc (Min) - BD787, BD788
- High Current-Gain Bandwidth Product fT = 50 MHz (Min) @ IC = 100 mAdc
- DC Current Gain Specified at 0.2, 1.0, 2.0 and 4.0 Adc
- Collector-Emitter Saturation Voltage Specified at 0.5, 1.0, 2.0 and 4.0 Adc

4 AMPERE **POWER TRANSISTORS** COMPLEMENTARY SILICON 45, 60VOLTS 15 WATTS

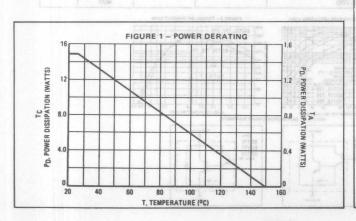


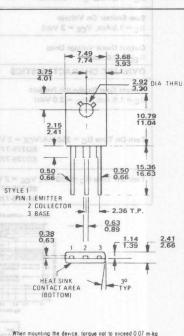
### \*MAXIMUM RATINGS

Rating	Symbol	BD785 BD786	BD787 BD788	Unit
Collector-Emitter Voltage	VCEO	45	60	Vdc
Collector-Base Voltage	VCBO	60	80	Vdc
Emitter-Base Voltage	VEBO	6	.0	Vdc
Collector Current - Continuous - Peak	Ic	4.0 8.0		Adc Adc
Base Current	I <sub>B</sub>	1.0		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate Above 25°C	PD	1 0.	5 12	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	8.34	°C/W





When mounting the device, torque not to exceed 0.07 m-kg

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend All dimensions in millimeters

**CASE 77-04** 

#### \*FLECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted.

Che	Symbol	Min	Max	Unit	
FF CHARACTERISTICS					
Collector-Emitter Sustaining Vol (IC = 10 mAdc, IB = 0)	tage (1) BD785, BD786 BD787, BD788	VCEO(sus)	45 60		Vdc
Collector Cutoff Current (V <sub>CE</sub> = 20 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)	BD785, BD786 BD787, BD788	ICEO	-	100 100	μAdc
Collector Cutoff Current (VCE = 60 Vdc, VBE(off) = 1.5 Vdc)	BD785, BD786	ICEX	-	1.0	μAdc
(V <sub>CE</sub> = 80 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc)	BD787, BD788			1.0	
(V <sub>CE</sub> = 30 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125 <sup>o</sup> C)	BD785, BD786			0.1	mAdc
(V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C	BD787, BD788			0.1	02
Emitter Cutoff Current (VEB = 6.0 Vdc, IC = 0)	2.0 5.0 10 20 4, NAME (ma)	BI IEBO EB	-50	1.0 and	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 1. <del>0</del> Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)		hFE A38A ONIT	40 25 20 5.0	250 ITOA	FIGUR 9
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 200 mAdc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 800 mAdc)		VCE(sat)		0.4 0.6 0.8 2.5	Vdc
Base-Emitter Saturation Voltage		VBE(sat)	⊕ ⊕arimira Sanderdane w	2.0 august	Vdc

### DYNAMIC CHARACTERISTICS

(IC = 2.0 Adc, VCE = 3.0 Vdc)

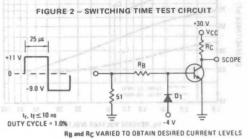
Base-Emitter on Voltage

Current-Gain — Bandwidth Product (IC = 100 mAdc, VCE = 10 Vdc,		one at f	85 50 0F	93 98 _ 81 48801333300 as	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>C</sub> = 0) f = 0.1 MHz)	BD785, BD787 BD786, BD788	Cob		50 70	pF
Small-Signal Current Gain (IC = 200 mAdc, VCE = 10 Vdc,	f = 1.0 kHz)	hfe	10	D SAUDIN	III Ti

VBE(on)

\*Indicates JEDEC Registered Data.

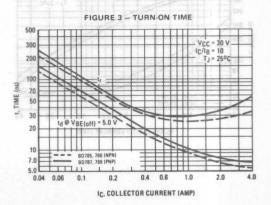
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%



D1 MUST BE FAST RECOVERY TYPE, eg:

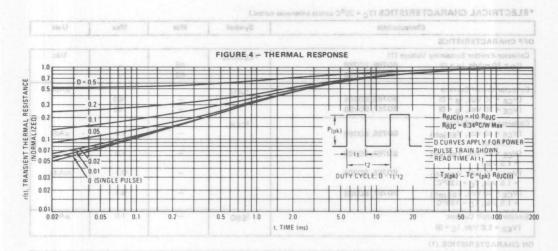
MBD5300 USED ABOVE IB ≈100 mA MSD6100 USED BELOW IB ≈100 mA

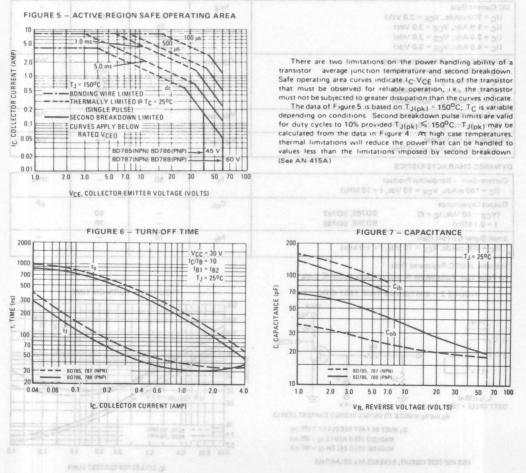
FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES



1.8

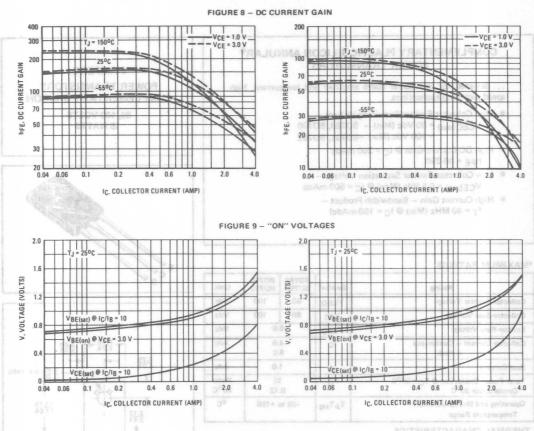
Vdc

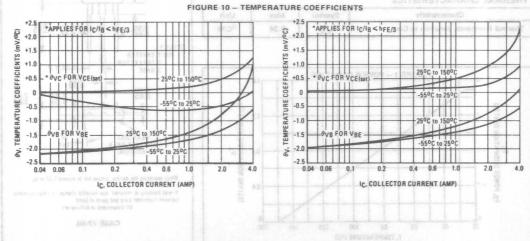






PNP BD786, BD788







## COMPLEMENTARY PLASTIC SILICON ANNULAR® **POWER TRANSISTORS**

... designed for low power audio amplifier and low-current, high speed switching applications.

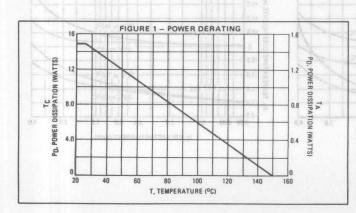
- High Collector-Emitter Sustaining Voltage -VCEO(sus) = 80 Vdc (Min) - BD789, BD790 = 100 Vdc (Min) -BD791, BD792
- High DC Current Gain @ IC = 200 mAdc hFF = 40-250
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 0.5 Vdc (Max) @ IC = 500 mAdc
- High Current Gain Bandwidth Product fT = 40 MHz (Min) @ IC = 100 mAdc)

#### \*MAXIMUM RATINGS

Rating	Symbol	BD789 BD790	BD791 BD792	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEBO	. 6	0.0	Vdc
Collector Current - Continuous - Peak	lc		1.0	Adc
Base Current	IB		1.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		15	Watts W/OC
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 t	o +150	°C

#### THERMAL CHARACTERISTICS

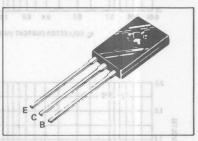
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	8.34	°C/W

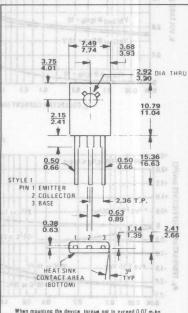


## 4 AMPERE

**POWER TRANSISTORS** COMPLEMENTARY SILICON

> 80, 100 VOLTS 15 WATTS





When mounting the device, torque not to exceed 0.07 m-kg

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend
All dimensions in millimeters

**CASE 77-04** 

3

FIGURE 5 - "ON" VOLTAGES

#### \*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic	HERMAL RESPONSE	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	H-1802 - 1007-1				01
Collector-Emitter Sustaining Voltage (1)	Colonia de la co	VCEO(sus)			Vdc
(I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)	BD789, BD790		80	-	
	BD791, BD792		100		
Collector Cutoff Current		ICEO			μAdc
(V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	BD789, BD790			100	
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	BD791, BD792			100	
Collector Cutoff Current		ICEX			
(VCE = 80 Vdc, VBE(off) = 1.5 Vdc)	BD789, BD790			1.0	μAdc
(VCE = 100 Vdc, VBE(off) = 1.5 Vdc)	BD791, BD792			1.0	
(VCE = 40 Vdc, VBE (off) = 1.5 Vdc, TC = 125°C				0.1	mAdc
(VCE = 50 Vdc, VBE(off) = 1.5 Vdc, TC = 125°C)	BD791, BD792			0.1	
Emitter Cutoff Current		1EBO		1.0	μAdc
(VEB = 6.0 Vdc, IC = 0)	28 50	0: 00		1.0 30.0	

#### ON CHARACTERISTICS (1)

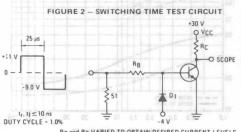
DC Current Gain	hFE			_
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 3.0 Vdc)		40	250	
(IC = 1.0 Adc, VCE = 3.0 Vdc)	an avitas .	20	-	
(IC = 2.0 Adc, VCE = 3.0 Vdc)		10	-	
(I <sub>C</sub> = 4:0 Adc, V <sub>CE</sub> = 3.0 Vdc)		5.0		
Collector-Emitter Saturation Voltage	VCE(sat)	- 14	BATT I	Vdc
(IC = 500 mAdc, IB = 50 mAdc)		P 2-1 - 1	0.5	
(IC = 1.0 Adc, IB = 100 mAdc)	7 003 /	100	1.0	
(I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 200 mAdc)		the Contract of	2.5	
(IC = 4.0 Adc, IB = 800 mAdc) siles tall be reade ad laure (Ed)	田文为生	A-1-1	3.0	
Base-Emitter Saturation Voltage (IC = 2.0 Adc, IB = 200 mAdc)	VBE(sat)	7 7 785 - 37	RAME BULSE	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 3.0 Vdc)	VBE(on)		WO JEE 1.5%A ZEVEL BATER VCCO	Vdc

#### DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product (IC = 100 mAdc, VCF = 10 Vdc, f = 10 MHz)	100 05 02	40	3.0 5.0 7.0	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>C</sub> = 0, f = 0.1 MHz BD789, BD791 BD790, BD792	C <sub>ob</sub>	n 30at 10v 8 31 718	50 70	pF
Small-Signal Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>fe</sub>	10 BMIT 390 MAU	FIGURE 6 - TE	

\*Indicates JEDEC Registered Data.

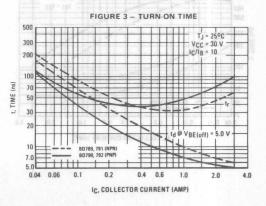
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.



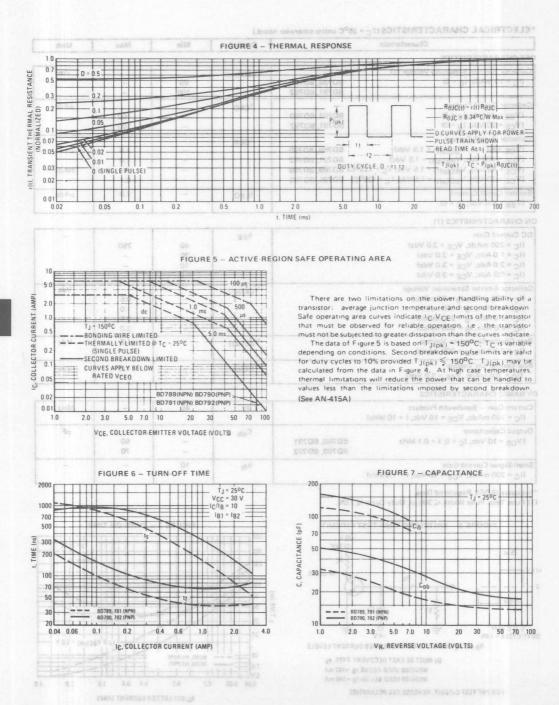
R<sub>B</sub> and R<sub>C</sub> VARIED TO OBTAIN DESIRED CURRENT LEVELS

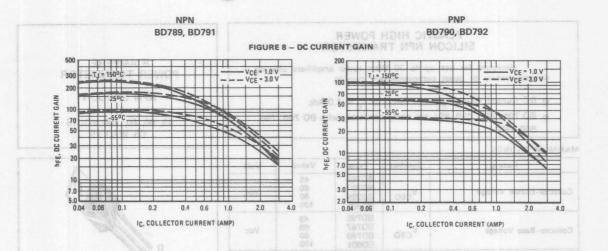
D1 MUST BE FAST RECOVERY TYPE, eg: MBD5300 USED ABOVE IB  $\approx$ 100 mA MSD6100 USED BELOW IB  $\approx$  100 mA

FOR PNP TEST CARCUIT, REVERSE ALL POLARITIES









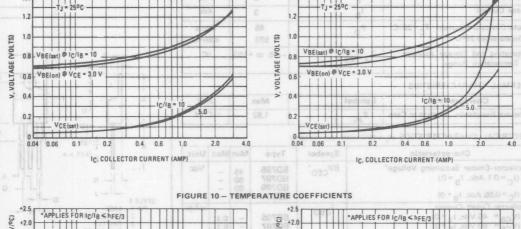
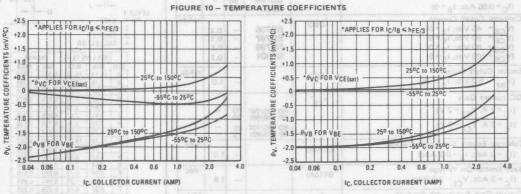


FIGURE 9 - "ON" VOLTAGES





## PLASTIC HIGH POWER SILICON NPN TRANSISTOR

designed for use up to 30 Watt audio amplifiers utilizing complementary or quasi complementary circuits.

- DC Current Gain—h<sub>FF</sub> = 40 (Min) @ I<sub>C</sub> = 1.0 Adc
- BD 795, 797, 799, 801 are complementary with BD 796, 798, 800, 802

#### MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD795 BD797 BD799 BD801	45 60 80 100	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD795 BD797 BD799 BD801	45 60 80 100	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	LIAGES	OV "MC 5 _ 8 9 6	U <sub>D</sub> Vdc
Collector Current	l'c	TOTAL	8	Adc
Base Current	B		3	Adc
Total Device Dissipation T <sub>C</sub> =25°C Derate avove 25°C	PD		65 522	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	8 (m) 30 V	_55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ 10	1,92	· C/W

## ELECTRICAL CHARACTERISTICS (T = 25°C unless otherwise noted)

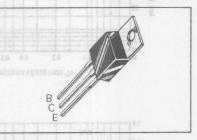
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0) (I <sub>C</sub> = 0.05 Adc, I <sub>B</sub> = 0)	BVCEO.	BD795 BD797 BD799 BD801	45 60 80 100		Vdc
Collector Cutoff Current (VCB = 45 Vdc, IE = 0) (VCB = 60 Vdc, IE = 0) (VCB = 80 Vdc, IE = 0) (VCB = 100 Vdc, IE = 0)	СВО	BD795 BD797 BD799 BD801		0.1 0.1 0.1 0.1	mAdd
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO	D+ 101		1.0	mAdo
DC current Gain (I <sub>C</sub> = 1 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 3 A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *	BD 795/797 BD 799/801 BD 795/797 BD 799/801	40 30 25	77	300 S
Collector-Emitter Saturation Voltage* (IC = 3 Adc, IB = 0.3 Adc)	VCE(sat)*	15- 1		1.0	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		-	1.6	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> =0.25Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	f <sub>T</sub>		3.0	-	MHz

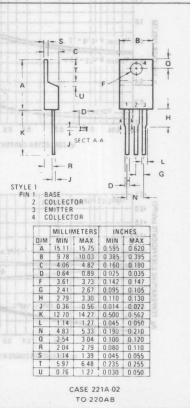
<sup>\*</sup> Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 2.0%.

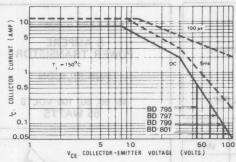
## 8 AMPERE POWER TRANSISTOR

NPN SILICON

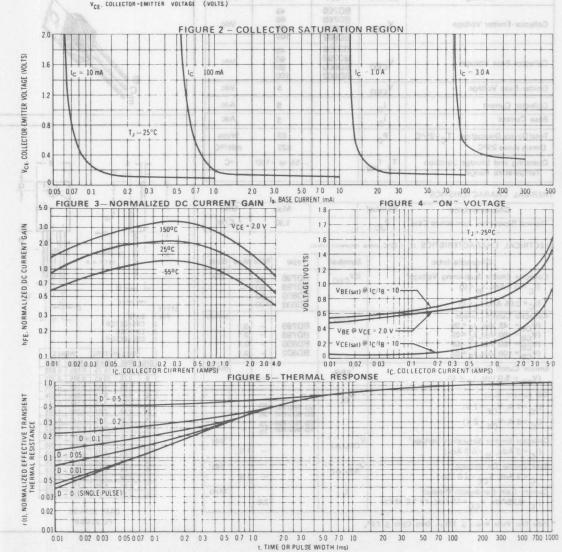
45, 60, 80, 100 VOLTS 65 WATTS







The Safe Operating Area Curves indicate  $I_C - V_{CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_J$ , power-temperature derating must be observed for both steady state and pulse power conditions.





#### PLASTIC HIGH POWER SILICON PNP TRANSISTOR

designed for use up to 30 Watt audio amplifiers utilizing complementary or quasi complementary circuits.

- DC Current Gain-h<sub>FE</sub> = 40 (Min) @ I<sub>C</sub> = 1.0 Adc
  - BD 796, 798, 800, 802 are complementary with BD 795, 797, 799, 801

## 45, 60, 80, 100 VOLTS 65 WATTS

8 AMPERE

POWER TRANSISTOR

PNP SILICON

#### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	VCEO	BD796 BD798 BD800 BD802	45 60 80 100	Vdc
Collector-Base Voltage	v <sub>СВО</sub>	BD796 BD798 BD800 BD802	45 60 80 100	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	l <sub>C</sub>		8	Adc
Base Current	I <sub>B</sub>		3	Adc
Total Device Dissipation T <sub>C</sub> =25°C Derate avove 25°C	PD		65 522	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		-55 to +150	°C

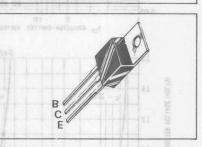
#### THERMAL CHARACTERISTICS

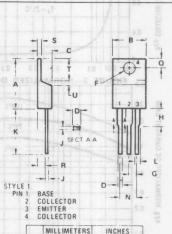
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θус	1.92	° C/W

## ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0) (I <sub>C</sub> = 0.05 Adc, I <sub>B</sub> = 0)	BVCEO	BD796 BD798 BD800 BD802	45 60 80 100		Vdc
Collector Cutoff Current (VCB = 45 Vdc, I <sub>E</sub> = 0) (VCB = 60 Vdc, I <sub>E</sub> = 0) (VCB = 80 Vdc, I <sub>E</sub> = 0) (VCB = 100 Vdc, I <sub>E</sub> = 0)	СВО	BD796 BD798 BD800 BD802	1111	0.1 0.1 0.1 0.1	mAdo
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO	THERMAL	0.6	1.0	mAdc
DC current Gain (I <sub>C</sub> = 1 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 3 A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *	BD 796/798 BD 800/802 BD 796/788 BD 800/802	40 30 25 15	I	
Collector Emitter Saturation Voltage* (I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 0.3 Adc)	VCE(sat)		-	1.0	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 2 0 Vdc)	VBE(on)		-	1 6	Vdc
Current-Gain-Bandwidth' Product (I <sub>C</sub> =0.25Adc, V <sub>CE</sub> =10 Vdc, f=1.0 MHz)	f <sub>T</sub>		3.0		MHz

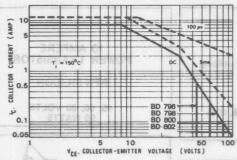
 $<sup>^{\</sup>circ}$  Pulse Test: Pulse Width  $\leq$  300  $\mu$ s. Duty Cycle  $\leq$  2.0%.



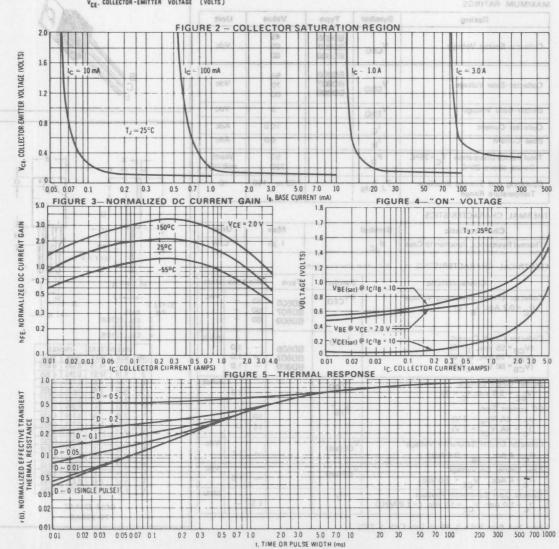


	MILLETIN	WE LEW?	INCHES	
DIM	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
В	9.78	10.03	0.385	0.395
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

CASE 221A-02 TO-220AB



The Safe Operating Area Curves indicate IC-VCE limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum TJ, power-temperature derating must be observed for both steady state and pulse power conditions.





## PLASTIC HIGH POWER SILICON NPN TRANSISTOR

... designed for use in high power audio amplifiers utilizing complementary or quasi complementary circuits.

- DC Current—h<sub>FE</sub> = 30 (Min) @ I<sub>C</sub> = 2.0 Adc
  - BD 805, 807, 809 are complementary with BD 806, 808, 810

## 10 AMPERE POWER TRANSISTOR

NPN SILICON

45, 60, 80 VOLTS 90 WATTS

#### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	BD805 BD807 BD809	45 60 80	Vdc
Collector-Base Voltage	V <sub>СВО</sub>	BD805 BD807 BD809	55 70 80	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>		5	Vdc
Collector Current	1 <sub>C</sub>		10.0	Adc
Base Current	I <sub>B</sub>		6.0	Adc
Total Device Dissipation T <sub>C</sub> = 25°C Derate above 25°C	PD		90 720	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	7.0 10	—55 to +150	°C

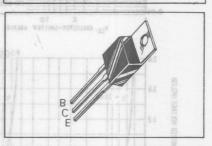
#### THERMAL CHARACTERISTICS

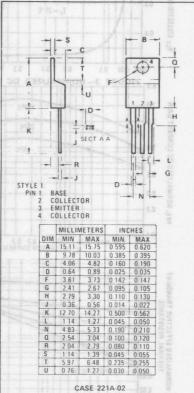
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θIC	1.39	° C/W

#### ELECTRICAL CHARACTERISTICS (T 25°C unless otherwise noted)

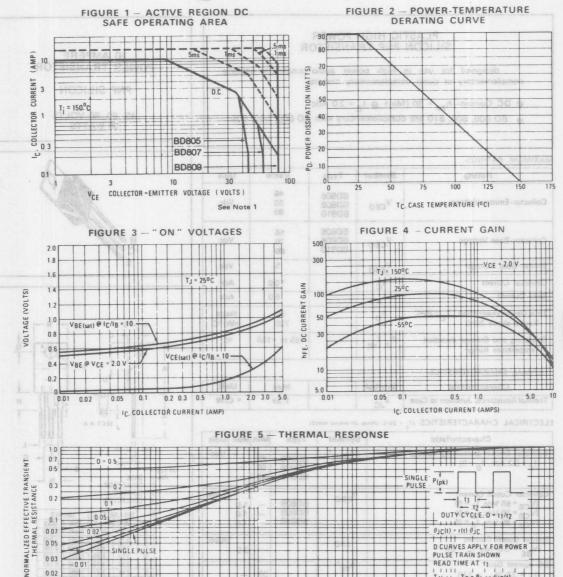
Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (IC = 0.2 Adc, IB = 0)	BVCEO	22000	45 60 80	1	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 55 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 70 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	1	BD805 BD807 BD809	- 0 - 0	1.0 1.0 1.0	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO			2.0	mAdc
DC current Gain	h <sub>FE</sub> *		30 15		
Collector-Emitter Saturation Voltage* (I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.4 Adc)	V <sub>CE(sat)</sub>			1.1	Vdc
Base-Emitter On Voltage* (I <sub>C</sub> = 4 Adc. V <sub>CE</sub> = 2.0 Vdc)	VBE(on)		-	1.6	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	<sup>1</sup> T		1.5		MHz

<sup>\*</sup> Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 20%.





TO-220AB



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC · VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

0.2 03 05

SINGLE PULSE

0.07 0 05

0.03

0.02

5 0.01

> The data of Figure 1 is based on  $T_{J(pk)}$  = 150°C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

D CURVES APPLY FOR POWER

PULSE TRAIN SHOWN

 $T_{J(pk)} - T_{C} = P_{(pk)} \theta_{JC}(t)$ 

READ TIME AT th

20 3.0 5.0 t, PULSE WIDTH (ms)



## PLASTIC HIGH POWER SILICON PNP TRANSISTOR

designed for use in high power audio amplifiers utilizing complementary or quasi complementary circuits.

- DC Current—h<sub>FF</sub> = 30 (Min) @ I<sub>C</sub> = 2.0 Adc
   BD 806, 808, 810 are complementary with BD 805, 807, 809

10 AMPERE POWER TRANSISTOR

PNP SILICON

45, 60, 80 VOLTS 90 WATTS

### MAXIMUM RATINGS

Rating	Symbol	Туре	Value	Unit
Collector-Emitter Voltage	VCEO	BD806 BD808 BD810	45 60 80	Vdc
Collector-Base Voltage	V <sub>CBO</sub>	BD806 BD808 BD810	55 70 80	Vdc
Emitter-Base Voltage	VEBO	000	5	Vdc
Collector Current	'c	-	10:0	Adc
Base Current	B	001	6.0	Adc
Total Device Dissipation T <sub>C</sub> =25°C Derate above 25°C	PD	1300	90 720	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stç</sub>	De 100	-55 to +150	°C

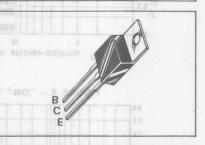
#### THERMAL CHARACTERISTICS

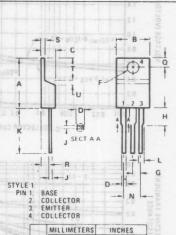
Characteristic	Symbol	Max	Unit
Thermal Résistance, Junction to Case	θ <sub>JC</sub>	1.39	° C/W

ELECTRICAL CHARACTERISTICS (T = 25"C unless of erwise noted)

Characteristic	Symbol	Туре	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I <sub>C</sub> = 0.2 Adc, I <sub>B</sub> = 0)	BVCEO	BD806 BD808 BD810	45 60 80		Vdc
Collector Cutoff Current (V <sub>CB</sub> = 55 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 70 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	СВО	BD806 BD808 BD810	-	1.0 1.0 1.0	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	EBO		-	2.0	mAdc
DC current Gain (I <sub>C</sub> = 2A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 4A, V <sub>CE</sub> = 2 V)	h <sub>FE</sub> *		30 15	-	
Collector-Emitter Saturation Voltage* (IC = 4 Adc, IB = 0.4 Adc)	V <sub>CE(sat)</sub>	98 98 3 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	0.1	1.1	Vdc
Base-Emitter On Voltage* (IC = 4 Adc, VCE = 2.0 Vdc)	VBE(on)	ontT	-	1.6	Vdc
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	tury of cles to eratures, thou	rio?	1.5	Stockers Stockers (7) Brain	MHz

<sup>\*</sup> Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 2.0%.



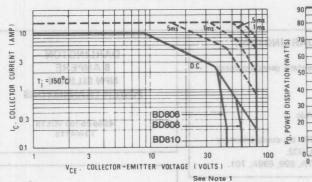


-	MILLIN	METERS	INC	HES
MIC	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
8	9.78	10.03	0.385	0.395
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0 147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0 210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

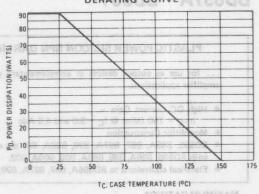
CASE 221A-02 TO-220AB

ALOHOTON

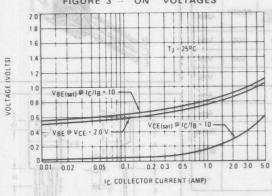
#### FIGURE 1 - ACTIVE REGION DC SAFE OPERATING AREA

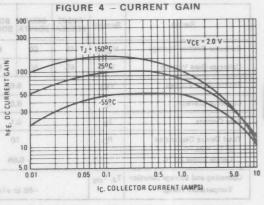


#### FIGURE 2 - POWER-TEMPERATURE DERATING CURVE

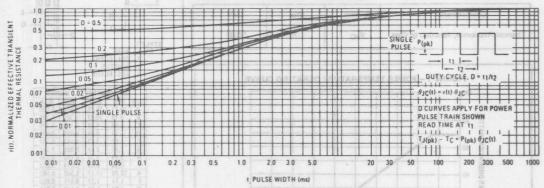


## FIGURE 3 - "ON" VOLTAGES





#### FIGURE 5 - THERMAL RESPONSE



#### Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> · V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

## PLASTIC POWER SILICON NPN DARLINGTONS

... for use as output devices in complementary general-purpose amplifier applications.

- High DC Current Gain –
   hFE = 750 (Min) @ I<sub>C</sub> = 3.0 and 4.0 Adc
- Monolithic Construction
- BD895, 895A, 897, 897A, 899, 899A, 901 are complementary with BD896, 896A, 898, 898A, 900, 900A, 902.
- Electrical equivalents to BD695A, 697, 697A, 699, 699A, 701.

## DARLINGTON 8 AMPERE NPN SILICON POWER TRANSISTORS

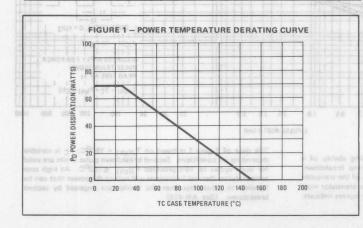
45-60-80-100 VOLTS 70 WATTS

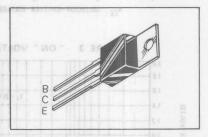
## MAXIMUM RATINGS

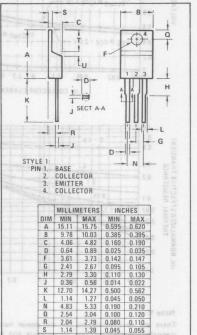
Rating	Symbol	BD895 BD895A	BD897 BD897A	BD899 BD899A	BD901	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	100	Vdc
Emitter-Base Voltage	VEB	5.0				Vdc
Collector Current	Ic	8.0				Adc
Base Current	IB	0.1			Adc	
Total Device Dissipation @T <sub>C</sub> = 25 °C	PD	70			Watts	
Derate above 25 °C			0.	56		W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	00	-55 t	o +150	20 20	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θјς	1.79	°C/W







CASE 221A-02

TO-220AB

## BD895, BD895A, BD897, BD897A, BD899, BD899A, BD901

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted)

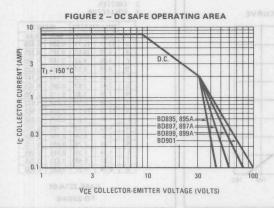
AJOROTOM

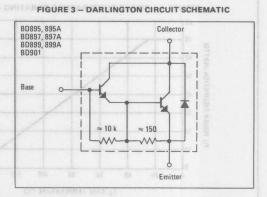
Char	acteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS	R3W09-MU	STIC MEDI			
Collector-Emitter Breakdown Voltage <sup>1</sup> (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BD895, 895A BD897, 897A BD899, 899A BD901	BV <sub>CEO</sub>	45 60 80 100	es s <u>n</u> u vol	Vdc
Collector Cutoff Current (VCE = Half Rated VCEO, IB = 0)	ah A G A A	ICEO	O toens	500	μAdc
Collector Cutoff Current (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0) (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0, T <sub>C</sub> = 100)	) °C)	СВО	Constru	0.2	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	filly vistnemelomop are soe in		998, 89 97, <del>-</del> 887		mAdc
ON CHARACTERISTICS	16A, 698, 606A, 700, 700A, 702	ents to 8D69	leviupe	[source]	9 0
DC Current Gain <sup>1</sup>	PD905 907 909 004	hFE	750	NATE AND	_
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	BD895, 897, 899, 901 BD895A, 897A, 899A		750	- "	AUMIX
		VCE(sat)		2.5	Vdc
(I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)  Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 12 mAdc)	BD895A, 897A, 899A BD895, 897, 899, 901	VCE(sat)		2.5	
(IC = 4.0 Adc, VCE = 3.0 Vdc)  Collector-Emitter Saturation Voltage (IC = 3.0 Adc, IB = 12 mAdc) (IC = 4.0 Adc, IB = 16 mAdc)  Base-Emitter On Voltage (IC = 3.0 Adc, VCE = 3.0 Vdc)	BD895A, 897A, 899A  BD895, 897, 899, 901  BD895A, 897A, 899A  BD895, 897, 899, 901	1000		2.5 2.8 2.5	Vdc

<sup>&</sup>lt;sup>1</sup> Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; e.g., the transistor must

not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown (see AN-415).







## PLASTIC MEDIUM-POWER PNP TRANSISTORS

. . for use as output devices in complementary general-purpose amplifier applications.

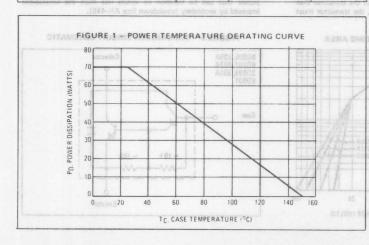
- High DC Current Gain hFE = 750 (Min) @ IC = 3.0 and 4.0 Adc loso
- Monolithic Construction
- BD896A, 898, 898A, 900, 900A, 902 are complementary with BD895A, 897, 897A, 899, 899A, 901
  - Electrical equivalents to BD696A, 698, 698A, 700, 700A, 702

## MAXIMUM RATINGS

		750				IM, 6350	es Alder	130
Vdc	Rating	in.	Symbol	BD696 BD696A	BD898 BD898A	BD900 BD900A	BD902	Unit
Collector-En	nitter Volta	ge	VCEO	45	60	80	100	Vdc
Collector-Ba	se Voltage	(m	VCB	45	60	80	100	Vdc
Emitter-Base Voltage		VEB	5.0				Vdc	
Collector Current		¹c	8.0				Adc	
Base Current			1 <sub>B</sub>	0.1				Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C		PD	70 0.56				Watts W/OC	
Operating and Storage Junction Temperating Range			T <sub>J</sub> , T <sub>stg</sub>		-55 to	+150	20	°C

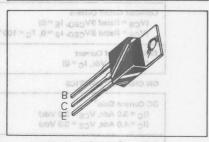
THERMAL CHARACTERISTICS

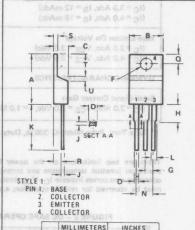
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	"JC	1.79	°C/W



DARLINGTON 8 AMPERE SILICON **POWER TRANSISTORS** 

> 45-60-80-100 VOLTS 70 WATTS





	MILLIMETERS		RS INCHES		
DIM	MIN	MAX	MIN	MAX	
A	15.11	15.75	0.595	0.620	
В	9.78	10.03	0.385	0.395	
C	4.06	4.82	0.160	0.190	
D	0.64	0.89	0.025	0.035	
F	3.61	3.73	0.142	0.147	
G	2.41	2.67	0.095	0.105	
H	2.79	3.30	0.110	0.130	
J	0.36	0.56	0.014	0.022	
K	12.70	14.27	0.500	0.562	
L	1.14	1.27	0.045	0.050	
N	4.83	5.33	0.190	0.210	
Q	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	
T	5.97	6.48	0.235	0.255	
U	0.76	1.27	0.030	0.050	

CASE 221A-02 TO-220AB

## BD896, 896A, BD898, 898A, BD900, 900A, BD902

## ELECTRICAL CHARACTERISTICS (TC - 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS		2	INAL/A	a nas	MAMIC
Collector-Emittèr Breakdown Voltage <sup>(1)</sup> (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BD896, 896A BD898, 898A BD900, 900A BD902	BVCEO	45 60 80 100	= -	Vdc
Collector Cutoff Current (V <sub>CE</sub> = Half Rated V <sub>CEO</sub> , I <sub>B</sub> = 0)	PLASTIC	ICEO	LEMENTA	500	μAdc
Collector Cutoff Current (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0) (V <sub>CB</sub> = Rated BV <sub>CEO</sub> , I <sub>E</sub> = 0, T <sub>C</sub> = 100°C)	tary general purpose	<sup>1</sup> CBO	- tput devices	0.2	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	cations	2.0	mAdc

## ON CHARACTERISTICS

ALOROTON

DC Current Gain <sup>(1)</sup> (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	BD896, 898, 900, 902 BD896A, 898A, 900A	hFE ni-rliu9 st	750 750	anolithte Col	IVI •
Collector-Emitter Saturation Voltage (IC = 3.0 Adc, IB = 12 mAdc)	BD896, 898, 900, 902	VCE (sat)	-	2.5	Vdc
(I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 16 mAdc)	BD896A, 898A, 900A	E Lowell	-	2.8	
Base-Emitter On Voltage (1)		VBE(on)		M RATINGS	Vdc
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	BD896, 898, 900, 902 BD896A, 898A, 900A	08 29 VG8 08 48 VGB	Symbol	2.5 2.5	Rating

#### DYNAMIC CHARACTERISTICS

Small-Signal Current Gain	hee	1.0	Caffeigns	the tolounyo
(IC = 3.0 Adc, VCE = 3.0 Vdc, f = 1.0 MHz)	···re	naV I	Voltage	Emitter-Base
C CL				S

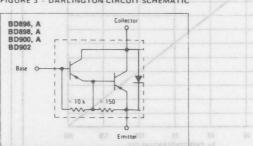
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

## FIGURE 2 - DC SAFE OPERATING AREA 10 T, = 150°C CURRENT COLLECTOR 03 01 VCE. COLLECTOR · EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)





## COMPLEMENTARY SILICON PLASTIC POWER DARLINGTONS

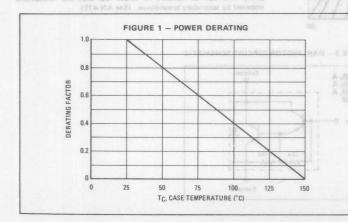
- ... for use as output devices in complementary general purpose amplifier applications.
- High DC Current Gain HFE = 1000 (min.) @ 5 Adc
- Monolithic Construction with Built-in Base Emitter Shunt Resistors

#### MAXIMUM RATINGS

Rating	Symbol	BDV 65 BDV 64	BDV 65A BDV 64A	BDV 65B BDV 64B	BDV 65C BDV 64C	Unit
Collector-Emitter Voltage	VCEO	60	80	100	120	V <sub>dc</sub>
Collector-Base Voltage	VCB	60	80	100	120	V <sub>dc</sub>
Emitter-Base Voltage	VEB	4371		5		V <sub>dc</sub>
Collector Current - Continuous - Peak	lc			0		A <sub>dc</sub>
Base Current	IB	A 3	BA ON O	.5 P3 0	DC SAPE	Adc
Total Device Dissipation  @ Tc = 25°C  Derate above 25°C	PD 125			Watts W/°C		
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	umit ou	- 65 to + 150			°C

#### THERMAL CHARACTERISTICS

Characteristic Characteristic	Symbol	Max.	Unit	
Thermal Resistance, Junction to Case	θJC 3A	1	°CM	

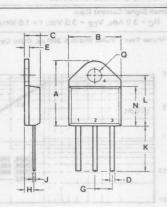


### DARLINGTONS 10 AMPERES

## COMPLEMENTARY SILICON POWER TRANSISTORS

60-80-100-120 VOLTS 125 WATTS





	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	2.41	3.20	0.095	0.126
1	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
0	4.04	4.22	0.159	0.166

CHIECTOR EMITTER VOLTAGE (VOLTS)

CASE 340-01 (TO-218AC)

3

20000, 526, 000, 500 800000, 5000, 5000

#### **ELECTRICAL CHARACTERISTICS**

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS			CURRENT GAIN	FIGURE 2 - DO	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	BDV65 -BDV64 BDV65A-BDV64A BDV65B-BDV64B	V <sub>CEO</sub> (sus)	60 80 100		Vdc
Collector Cutoff Current	BDV65C-BDV64C	I <sub>CEO</sub>	120		mAdc
(V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)	BDV65 -BDV64 BDV65A-BDV64A BDV65B-BDV64B BDV65C-BDV64C	CEO		1 1 1 1	MAGE
Collector Cutoff Current $(V_{CB} = 60 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 80 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 100 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 120 \text{ Vdc}, I_E = 0)$	BDV65 -BDV64 BDV65A-BDV64A BDV65B-BDV64B BDV65C-BDV64C	Ісво	CALTHERAND O	.4 .4 .4 .4	mAdc
Collector Cutoff Current $ \begin{aligned} (V_{CB} &= 30 \text{ Vdc, } I_E = 0, T_C = 150^{\circ}\text{C}) \\ (V_{CB} &= 40 \text{ Vdc, } I_E = 0, T_C = 150^{\circ}\text{C}) \\ (V_{CB} &= 50 \text{ Vdc, } I_E = 0, T_C = 150^{\circ}\text{C}) \\ (V_{CB} &= 60 \text{ Vdc, } I_E = 0, T_C = 150^{\circ}\text{C}) \end{aligned} $	BDV65 -BDV64 BDV65A-BDV64A BDV65B-BDV64B BDV65C-BDV64C	Ісво	ON" VOLTAGES	2 2 2 2	mAdc
Emitter Cutoff Current $(V_{BE} = 5 \text{ Vdc}, I_C = 0)$		I <sub>EBO</sub>		5	mAdc
ON CHARACTERISTICS		-			
DC Current Gain $(I_C = 5 \text{ Adc}, V_{CE} = 4 \text{ Vdc})$	al/ol/@ castabk = 1 3	HFE	1000	665 m 211.95	(141)53 <sup>11</sup>
Collector-Emitter Saturation Voltage $(I_C = 5 \text{ Adc}, I_B = 0.02 \text{ Adc})$		V <sub>CE</sub> (sat)		2	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5 Adc, V <sub>CF</sub> = 4 Vdc)	1.0	V <sub>BE</sub> (on)		2.5	Vdc





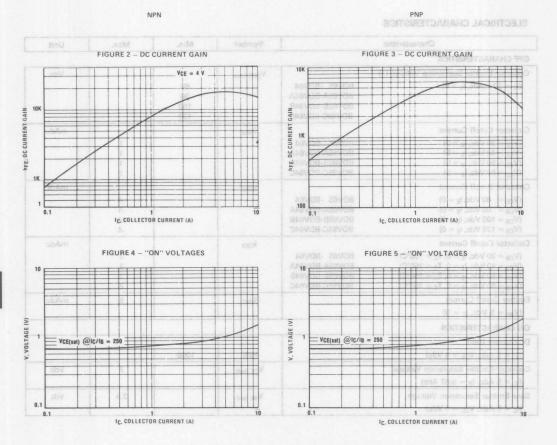
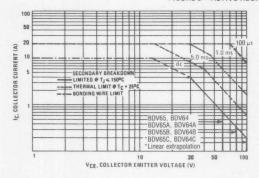


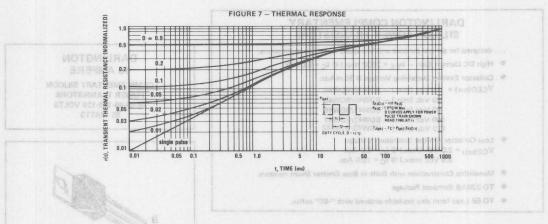
FIGURE 6 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second break down. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 6 is based on TJ(pk) 150°C, TC is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{9}$ /o provided TJ(pk)  $\leq 150^{\circ}$ C. TJ(pk) may be calculated from the data in figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A)

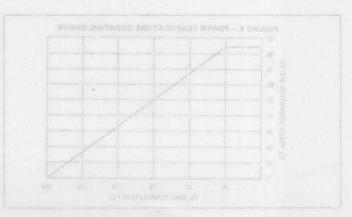
NPN PNP BDW39 BDW44 BDW40 BDW45 BDW41 BDW46 BDW42 BDW47 BDW43 BDW48



J	N TOTAL STREET	- a	T I I I I I I I I I I I I I I I I I I I	

	BDW45		

		THERMAL CHARACTERISTICS
tinU		



## DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general purpose and low speed switching applications.

- High DC Current Gain hFE = 2500 (typ.) @ IC = 5.0 Adc.
- Collector Emitter Sustaining Voltage @ 30 mAdc:

VCEO(sus) = 45 Vdc (min.) – BDW39/BDW44

60 Vdc (min.) - BDW40/BDW45 80 Vdc (min.) - BDW41/BDW46

100 Vdc (min.) - BDW42/BDW47 120 Vdc (min.) - BDW43/BDW48

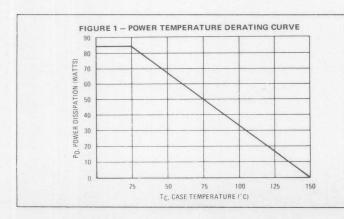
- Low Collector Emitter Saturation Voltage:
   V<sub>CE</sub>(sat) = 2.0 Vdc (max.) @ I<sub>C</sub> = 5.0 Adc 3.0 Vdc (max.) @ I<sub>C</sub> = 10.0 Adc
- Monolithic Construction with Built-In Base Emitter Shunt resistors
- TO-220AB €ompact Package
- TO-66 Lead form also available ordered with "-66" suffix.

#### MAXIMUM RATINGS

Rating	Symbol	BDW39 BDW44	BDW40 BDW45	BDW41 BDW46	BDW42 BDW47	BDW43 BDW48	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	120	V <sub>dc</sub>
Collector-Base Voltage	VCB	45	60	80	100	120	Vdc
Emitter-Base Voltage	VEB	5.0					
Collector Current - Continuous	1 <sub>C</sub>	15					Adc
Base Current	IB	0.5					A <sub>dc</sub>
Total Device Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	85 0.68					Watts W/°C
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-55 to +150					°C

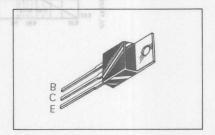
#### THERMAL CHARACTERISTICS

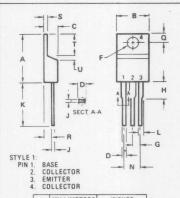
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	Rejc	1.47	°C/W



### DARLINGTON 15 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS 45-60-80-100-120 VOLTS 85 WATTS





	MILLIN	METERS	INCHES			
DIM	MIN	MAX	MIN	MAX		
A	15.11	15.75	0.595	0.620		
В	9.78	10.03	0.385	0.395		
C	4.06	4.82	0.160	0.190		
D	0.64	0.89	0.025	0.035		
F	3.61	3.73	0.142	0.147		
G	2.41	2.67	0.095	0.105		
Н	2.79	3.30	0.110	0.130		
J	0.36	0.56	0.014	0.022		
K	12.70	14.27	0.500	0.562		
L	1.14	1.27	0.045	0.050		
N	4.83	5.33	0.190	0.210		
Q	2.54	3.04	0.100	0.120		
R	2.04	2.79	0.080	0.110		
S	1.14	1.39	0.045	0.055		
T	5.97	6.48	0.235	0.255		
U	0.76	1.27	0.030	0.050		

CASE 221A-02 TO-220AB

## BDW39, BDW40, BDW41, BDW42, BDW43 NPN BDW44, BDW45, BDW46, BDW47, BDW48 PNP

**ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Min. Max. Unit Characteristic Symbol OFF CHARACTERISTICS V<sub>CEO(sus)</sub> Collector Emitter Sustaining Voltage 1 Vdc 45 BDW39/BDW44  $(I_C = 30 \text{ mAdc}, I_B = 0)$ RDW40/RDW45 60 BDW41/BDW46 80 BDW42/BDW47 100 BDW43/BDW48 120 Collector Cutoff Current ICEO mAdc  $(V_{CF} = 22.5 \, Vdc, I_B = 0)$ BDW39/BDW44 2 BDW40/BDW45 2  $(V_{CE} = 30 \quad Vdc, I_B = 0)$  $(V_{CE} = 40 \quad Vdc, I_B = 0)$ BDW41/BDW46 2  $(V_{CE} = 50 \quad Vdc, I_B = 0)$ BDW42/BDW47 2  $(V_{CE} = 60 \text{ Vdc}, I_B = 0)$ BDW43/BDW48 Collector Cutoff Current mAdc  $(V_{CB} = 45 \, Vdc, I_E = 0)$ BDW39/BDW44  $(V_{CB} = 60 \text{ Vdc}, I_E = 0)$ BDW40/BDW45  $(V_{CB} = 80 \text{ Vdc}, I_E = 0)$ BDW41/BDW46  $(V_{CB} = 100 \text{ Vdc}, I_E = 0)$ BDW42/BDW47  $(V_{CB} = 120 \, Vdc, I_E = 0)$ BDW43/BDW48 Emitter Cutoff Current mAdc I<sub>EBO</sub>  $(V_{BE} = 5.0 \text{ Vdc}, I_{C} = 0)$ 2 ON CHARACTERISTICS1 DC Current Gain hFE  $(I_C = 5 Adc, V_{CE} = 4.0 Vdc)$ 1000  $(I_C = 10 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc})$ 250 for all except BDW43/48 for BDW 43/48 250 Collector-Emitter Saturation Voltage V<sub>CE</sub> (sat.) Vdc  $(I_C = 5 Adc, I_B = 10 mAdc)$ 2  $(I_C = 10 \text{ Adc}, I_B = 50 \text{ mAdc})$ 3 Base-Emitter On Voltage VBE (on) Vdc  $(I_C = 10 \text{ Adc}, V_{CE} = 4 \text{ Vdc})$ 3 SECOND BREAKDOWN<sup>2</sup> Second Breakdown Collector I<sub>S/b</sub> Adc Current with Base Forward Biased  $V_{CE} = 28.4 \text{ Vdc}$ 3 BDW39/BDW40/BDW41/BDW42/BDW43  $V_{CE} = 40 \text{ Vdc}$ 1.2  $V_{CE} = 22.5 \text{ Vdc}$ 3.8 BDW44/BDW45/BDW46/BDW47/BDW48 V<sub>CE</sub> = 36 Vdc 1.2 **DYNAMIC CHARACTERISTICS** Magnitude of common emitter small signal short circuit current transfer ratio fT MHz ( $I_C = 3.0$  Adc,  $V_{CE} = 3.0$  Vdc, f = 1.0 MHz) 4.0 Output capacitance PF Cob  $(V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 0.1 \text{ MHz})$ BDW39/BDW40/BDW41/BDW42/BDW43

Indicates JEDEC Registered Data.

Small signal current gain

BDW44/BDW45/BDW46/BDW47/BDW48

 $I_C = 3.0 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc}, f = 1.0 \text{ kHz})$ 

h<sub>fe</sub>

300

200

<sup>&</sup>lt;sup>1</sup> Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle = 2.0 %.

<sup>&</sup>lt;sup>2</sup> Pulse Test non repetitive: Pulse Width = 250 ms.

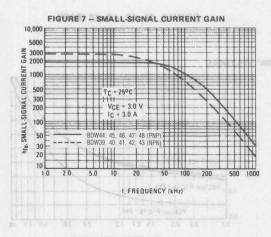
#### FIGURE 2 - SWITCHING TIMES TEST CIRCUIT FIGURE 3 - SWITCHING TIMES 5.0 2.0 RB & RC VARIED TO OBTAIN DESIRED CURRENT LEVELS 01, MUST BE FAST RECOVERY TYPES, e.g., MBD5300 USED ABOVE IB ~ 100 mA MSD6100 USED BELOW IB ~ 100 mA 1.0 0.7 t, TIME ( 0.5 appro +8.0 V 0.3 0.2 VCC = 30 V TJ = 250C td @ VBE(off) = 0 V 0.1 for to and tr. D1 is disconnected - 25 us - PN DUTY CYCLE - 1.0% 0.2 0.5 0.7 1.0 IC, COLLECTOR CURRENT (AMP) FIGURE 4 - THERMAL RESPONSE EFFECTIVE TRANSIENT C. 0.00 C. 0.7 D = 0.5 $R_{\theta JC}(t) = r(t)R_{\theta JC}$ ROJC = 1.920C/W D CURVES APPLY FOR POWER PULSE TRAIN SHOWN READ TIME AT to 0.02 t1 TJ(pk) - TC = P(pk) ReJC(t) E0.03 DUTY CYCLE, D = t1/t2 -0.01 Single Pulse H 0.02 t, TIME OR PULSE WIDTH (ms) **ACTIVE-REGION SAFE OPERATING AREA** FIGURE 5 - BDW39 THRU BDW43 FIGURE 6 - BDW44 THRU BDW48 50 10 10 COLLECTOR CURRENT 5.0 CURRENT 5.0 SECOND BREAKDOWN SECOND BREAKDOWN LIMIT FOR BONDING WIRE LIMI - BONDING WIRE LIMIT 0.5 COLLECT 0.5 THERMAL LIMITED THERMAL LIMITED @ Tr = 25 °C (Single Pulse) @ Tc = 25 °C (Single Pulse) 0.2 0.3 5 0.1 BDW41 0.1 BDW42 BDW43 0.05 0.05 \*BDW48-1.0 2.0 3.0 5.0 7.0 10 20 30 5.0 7.0 10 20 30 50 VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS) VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS) There are two limitations on the power handling ability of a 200 °C; TC is variable depending on conditions. Second breakdown pulse, limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200\,^{\circ}\text{C}$ . $T_{J(pk)}$ may be calculated from the data in Fig. 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC — VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the

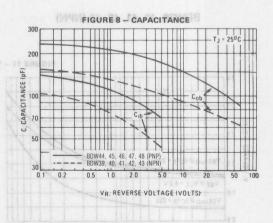
imposed by second breakdown. (See an-415).

\*Linear extrapolation

curves indicate. The data of Fig. 5 and 6 is based on TJ(pk) =

## BDW39, BDW40, BDW41, BDW42, BDW43 NPN SAMGE TAWGE CAWGE REWGE BDW44, BDW45, BDW46, BDW47, BDW48 PNP

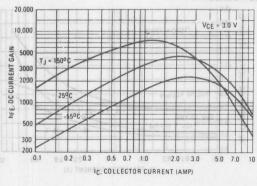


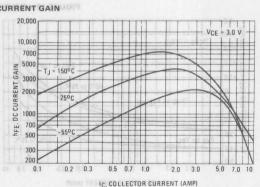


BDW39, 40, 41, 42, 43 (NPN)

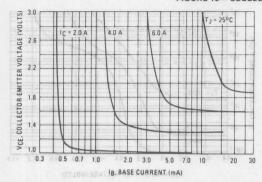
BDW44, 45, 46, 47, 48 (PNP)

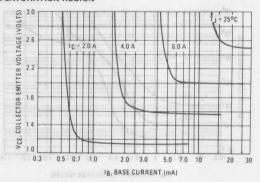


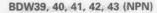




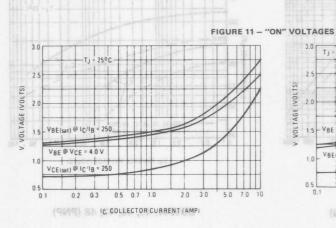
#### FIGURE 10 - COLLECTOR SATURATION REGION

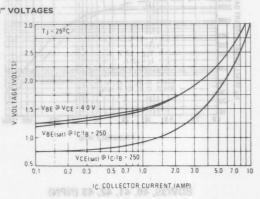




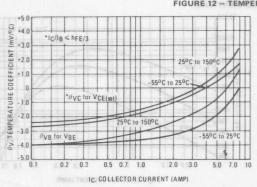


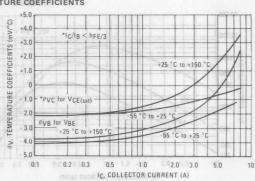
## BDW44, 45, 46, 47, 48 (PNP)



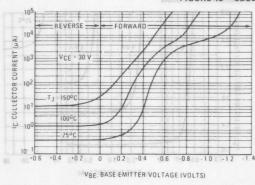


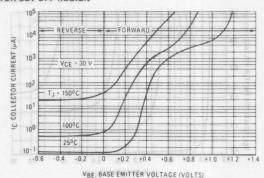
#### FIGURE 12 - TEMPERATURE COEFFICIENTS





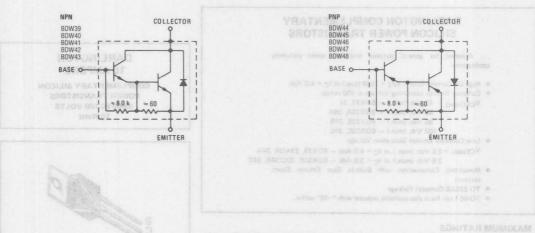
### FIGURE 13 - COLLECTOR CUT-OFF REGION





BDW39, BDW40, BDW41, BDW42, BDW43 NPN BDW44, BDW45, BDW46, BDW47, BDW48 PNP NPN PNP BDX33 BDX34 BDX33A BDX34A BDX33C BDX34B

#### FIGURE 14 - DARLINGTON SCHEMATIC



		MAXIMUM RATINGS						
							Rating	
	ohV							
							Total Device Dissipation  © TC = 25 °C  Devate above 25 °C	
AA TORE								
0								
32A3 1BR9							Thermal Plusistance, Junction to Care	



J



# DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general purpose and low speed switching applications.

- High DC Current Gain hFF = 2500 (typ.) at IC = 4.0 Adc
- Collector Emitter sustaining Voltage at 100 mAdc

VCEO(sus) = 45 Vdc (min.) - BDX33, 34

60 Vdc (min.) – BDX33A, 34A 80 Vdc (min.) – BDX33B, 34B

100 Vdc (min.) - BDX33C, 34C

Low Collector Emitter Saturation Voltage

VCE(sat) = 2.5 Vdc (max.) at I<sub>C</sub> = 4.0 Adc - BDX33, 33A/34, 34A 2.5 Vdc (max.) at I<sub>C</sub> = 3.0 Adc - BDX33B, 33C/34B, 34C

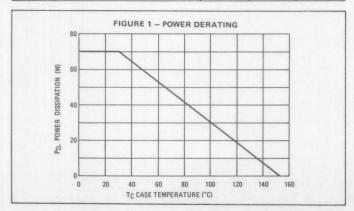
- Monolithic Construction with Built-In Base Emitter Shunt
- resistors
- TO-220AB Compact Package
- TO-66 Lead form also available ordered with "-66" suffix.

### MAXIMUM RATINGS

Rating	Symbol	BDX33 BDX34	BDX33A BDX34A	BDX33B BDX34B	BDX33C BDX34C	Unit
Collector-Emitter Voltage	VCEO	45	60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	100	Vdc
Emitter-Base Voltage	VEB	5.0				Vdc
Collector Current - Continuous Peak	lc	10 15				Adc
Base Current	IB	0.25				Adc
Total Device Dissipation  @ T <sub>C</sub> = 25 °C  Derate above 25 °C	PD	70 0.56				Watts W/° C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150				°C

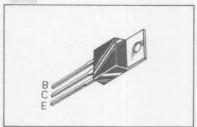
### THERMAL CHARACTERISTICS

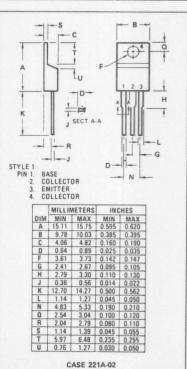
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.78	°C/W



### DARLINGTON 10 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS 45-60-80-100 VOLTS 70 Watts





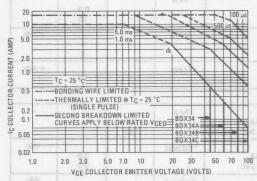
TO-220AB

### BDX33, BDX33A, BDX33B, BDX33C NPN M9M DEEXER REEXER ASENDE EEXER BDX34, BDX34A, BDX34B, BDX34C PNP

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage <sup>1</sup>		VCEO(sus)		110	Vdc
(I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BDX33/BDX34		45		5.0
D CURVES APPLY FOR POWER	BDX33A/BDX34A		60	1.0	
PULSE TRAIN SHOWN	BDX33B/BDX34B		80	200	
11 TA SHOT CASE	BDX33C/BDX34C		100		
Collector-Emitter Sustaining Voltage 1		VCER(sus)		THE	Vdc
(I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0, R <sub>BE</sub> = 100)	BDX33/BDX34		45		
			60 80	pm2 10.0	
	BDX33B/BDX34B BDX33C/BDX34C		100		
Callegae Emissa Consider Valare 1	BDX33C/BDX34C	V	100		Vdc
Collector-Emitter Sustaining Voltage <sup>1</sup> (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0, V <sub>BE</sub> = 1.5 Vdc)	BDX33/BDX34	VCEX(sus)	45	0.02 0.03 %	10.0
(IC - 100 MAde, IB - 0, VBE - 1.5 Vdc)	BDX33A/BDX34A		60		
	BDX33B/BDX34B		80		
	BDX33C/BDX34C		100	11.1	
Collector Cutoff Current	STIVE REGION SAFE OPERATIN	ICEO			mAde
(VCE = ½ rated VCEO, IB = 0)	T <sub>C</sub> = 25 °C			0.5	
	T <sub>C</sub> = 100 °C		MILL	10	
Collector Cutoff Current		ІСВО	200		mAde
(V <sub>CB</sub> = rated V <sub>CBO</sub> , I <sub>E</sub> = 0)	T <sub>C</sub> = 25 °C			1	
	T <sub>C</sub> = 100 °C	1		5	0
Emitter Cutoff Current		IEBO			mAd
(V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)				10	
ON CHARACTERISTICS	HD2				
DC Current Gain 1	3.0 5	hee	#370m r.m/0	NAMES PROPERTY	-5
(IC = 4.0 Adc, VCE = 3.0 Vdc)	BDX33, 33A/34, 34A	DEO PROXIDE	750	URVES APPLYS	
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	BDX33B, 33C/34B, 34C	00X34B	750		
Collector-Emitter Saturation Voltage		VCE(sat)			Vdc
(IC = 4.0 Adc, IB = 8 mAdc)	BDX33, 33A/34, 34A	20 30	07 0.7 0	2.5	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 6 mAdc)	BDX33B, 33C/34B, 34C	THOU BOATHOU	STILL BETTER	2.5	
Base-Emitter On Voltage	n sidelini si aT	VBE(on)			Vdc
(IC = 4.0 Adc, VCE = 3 V)	BDX33, 33A/34, 34A	Amonas ban on	Estagraet and	2.5	
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3 Vdc) mod balalusia	BDX33B, 33C/34B, 34C	10 - VCE	orasismi savo	2.5	redo oper
Diode Forward Voltage		VF	of Barrago	ed fon seum	Vdc
(I <sub>C</sub> = 8 Adc)	ser) = 150°Cl   breakdown (see	DET no beard	a of Fig. 6 is	so of and	pur savar
SECOND BREAKDOWN <sup>2</sup>					
Second Breakdown Collector Current		I <sub>S/b</sub>			Adc
With Base Forward Biased	GAIN	AL CURREN	MALL-SIGN	HEURE 4 - 6	
(VCE = 25 Vdc)	BDX33 Series	N 7 1 1 1 2 2 7 1 1 Y	2.8	0470 - 1-9	
(V <sub>CE</sub> = 20 Vdc)	BDX34 Series		3.5		
(V <sub>CE</sub> = 36 Vdc)	BDX33 Series BDX34 Series		1.0		
(V <sub>CE</sub> = 33 Vdc)	DUAG4 Series		1.0		800
DYNAMIC CHARACTERISTICS		100			000
Small-Signal Current Gain		HEE	1 2420		002
		4/ 1111	1000		350
(T <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1 MHz)					
		fT	20V 0.8 = 3		MHz
(T <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1 MHz)	or §	fŢ	3		MHz
(T <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1 MHz)  Current Gain-Bandwidth product	01 5	f <sub>T</sub>	3	9/9	MHz pF
(T <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1 MHz)  Current Gain-Bandwidth product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc, f = 1.0 MHz)	BDX33 Series BDX34 Series		3	200	001

 $<sup>^1</sup>$  Pulse Test: Pulse Width  $\leq 300~\mu s,$  Duty Cycle  $\leq 2\%$  Pulse Test non repetitive: Pulse Width = 0.25 s.

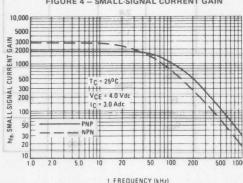


-1.0 ms-2.0 1.0 BONDING WIRE LIMITED COLLECTOR 0.5 (SINGLE PULSE) 0.2 SECOND BREAKDOWN LIMITED 0.1 BDX33A= 2 0.05 BDX33C 1.0 2.0 3.0 5.0 7.0 10 20 30 VCE COLLECTOR EMITTER VOLTAGE (VOLTS)

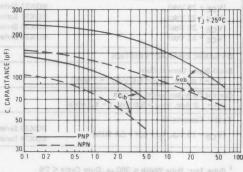
BDX34, BDX34A, BDX34B, BDX34C PNP

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I $_{\rm C}-{\rm V}_{\rm CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Fig. 3 is based on  $T_{J(pk)} = 150$  °C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}$  150 °C  $T_{J(pk)}$  may be calculated from the data in Fig. . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown (see AN-415A).

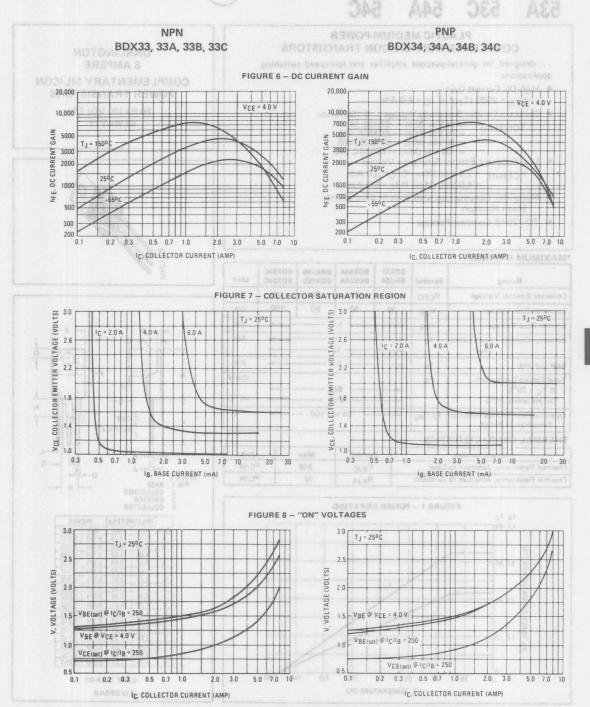




### FIGURE 5 - CAPACITANCE



VA. REVERSE VOLTAGE (VOLTS)





### PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

... designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain -
- hFE = 2500 (Typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mAdc

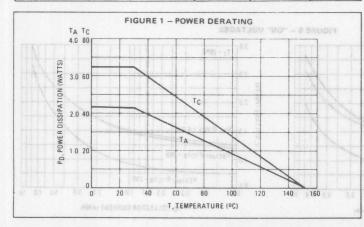
- VCEO(sus) = 45 Vdc (Min) BDX53, 54 = 60 Vdc (Min) BDX53A, 54A = 80 Vdc (Min) BDX53B, 54B = 100 Vdc (Min) BDX53C, 54C
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 2.0 Vdc (Max) @ IC = 3.0 Adc
  - = 4.0 Vdc (Max) @ IC = 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
- TO-220AB Compact Package

### \*MAXIMUM RATINGS

Rating	Symbol	BDX53 BDX54	BDX53A BDX54A	BDX53B BDX54B	BDX53C BDX54C	Unit
Collector-Emitter Voltage	VCEO	45	и 60	80	100	Vdc
Collector-Base Voltage	VCB	45	60	80	1.00	Vdc
Emitter-Base Voltage	VEB	-	5.	0	-	Vdc
Collector Current Continuous Peak	A U.A C	A 0.5 - 31	12		-	Adc
Base Current	1 <sub>B</sub>		0.	2 —	-	Adc
Total Device Dissipation  @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	-	60			Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> .T <sub>stg</sub>	1-1	- 65 to	0 +150 -		°C

### THERMAL CHARACTERISTICS

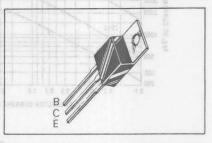
Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	2.08	°C/W
Thermal Resistance, Junction to Ambient	ReJA	70	°C/W

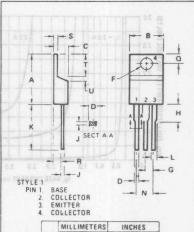


### DARLINGTON 8 AMPERE

### COMPLEMENTARY SILICON POWER TRANSISTORS

60-80-100 VOLTS 65 WATTS



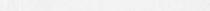


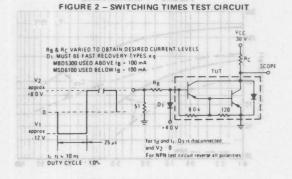
	MILLI	METERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
A	15 11	15.75	0.595	0.620
В	9.78	10.03	0.385	0.395
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
1	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

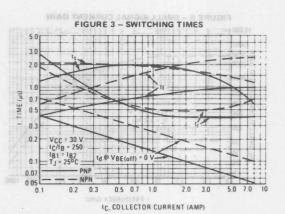
IN ADTES TO 220AB

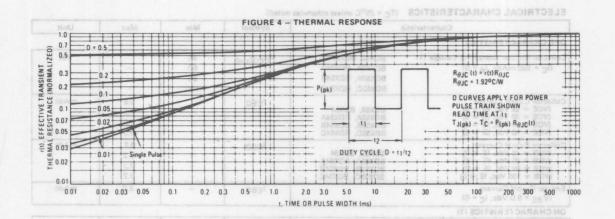
### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

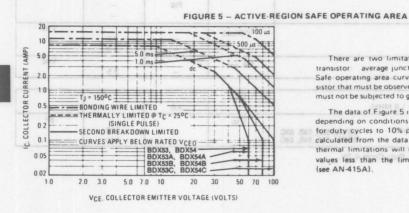
Characteristic	Paris tour determinant	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BDX53, BDX54 BDX53A, BDX54A BDX53B, BDX54B BDX53C, BDX54C	VCEO(sus)	45 60 80 100	-	Vdc
Collector Cutoff Current (VCE = 22 Vdc, IB = 0) (VCE = 30 Vdc, IB = 0) (VCE = 40 Vdc, IB = 0) (VCE = 50 Vdc, IB = 0)	BDX53, BDX54 BDX53A, BDX54A BDX53B, BDX54B BDX53C, BDX54C	ICEO		0.5 0.5 0.5 0.5	mAdc
Collector Cutoff Current (VCB = 45 Vdc, IE = 0) (VCB = 60 Vdc, IE = 0) (VCB = 80 Vdc, IE = 0) (VCB = 100 Vdc, IE = 0)	BDX53, BDX54 BDX53A, BDX54A BDX53B, BDX54B BDX53C, BDX54C	Ісво	<u>-</u>	0.2 0.2 0.2 0.2	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	- 01	I IEBO	6.0 S.0 = 6.2 O.8	2.0 50	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (IC = 3.0 Adc, VCE = 3.0 Vdc)	EGION SAFE OPERATING	hFE ACTIVE-P	750	_	
Collector-Emitter Saturation Voltage ( $I_C = 3.0 \text{ Adc}$ , $I_B = 12 \text{ mAdc}$ )		VCE(sat)		2.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>C</sub> = 12 mA)	pereve totaleness	V <sub>BE</sub> (sat)	- To	2.5	Vdc
DYNAMIC CHARACTERISTICS	estor that must be	11			
Small-Signal Current Gain $(I_C = 3.0 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc}, f = 1.0 \text{ M})$		Ihfel	4.0	A 1909c + 17 DNOINC =186 CHE	20
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	BDX53, 53A, 53B, 53C	C <sub>ob</sub>	(32.) (31.) (31.) (31.) (31.) (31.) (31.) (31.) (31.) (31.) (31.)	300 200	pF 0
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty	Cycle ≤ 2%.	HIP-	BOXEN BOXEN		20 0





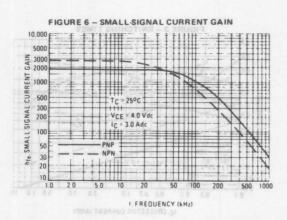


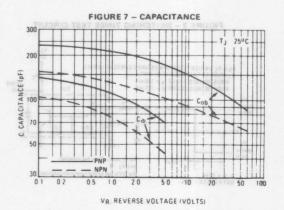




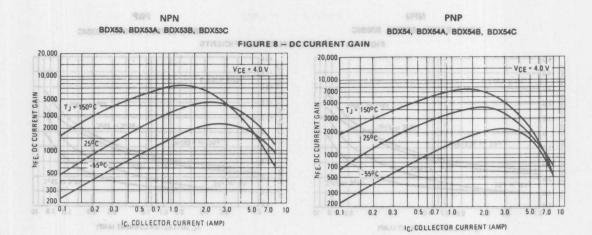
There are two limitations on the power handling ability of a transistor—average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate

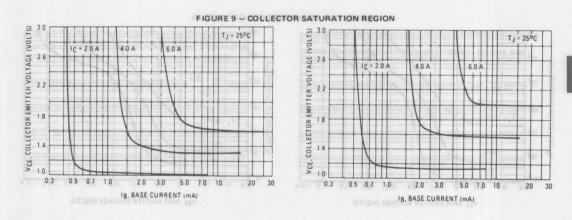
The data of Figure 5 is based on  $T_{J(pk)} \simeq 150^{\circ} C$ .  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$  provided  $T_{J(pk)} < 150^{\circ} C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown (see AN-415A).

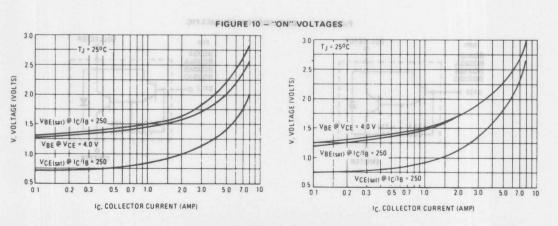


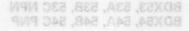






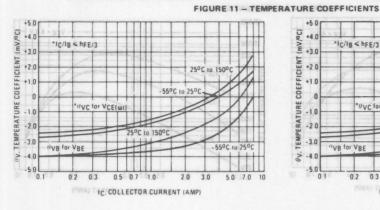


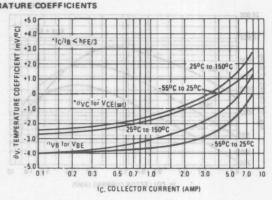




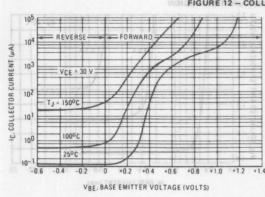
NPN
BDX53, BDX53A, BDX53B, BDX53C

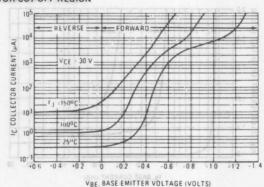
PNP BDX54, BDX54A, BDX54B, BDX54C



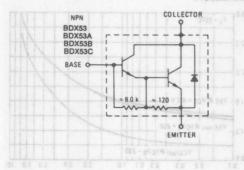


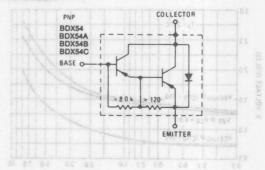
### FIGURE 12 - COLLECTOR CUT-OFF REGION





### FIGURE 13 - DARLINGTON SCHEMATIC





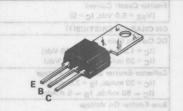


# NPN SILICON ANNULAR® HIGH VOLTAGE AMPLIFIER TRANSISTORS

. . . designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage —
   BVCEO = 350 Vdc (Min) @ IC = 1.0 mAdc BF462
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.6 Vdc (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance —
   C<sub>cb</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 20 Vdc
- Duowatt Package –
   2 Watts Free Air Dissipation @ T<sub>Δ</sub> = 25°C
- Complements to PNP BF463/464/465



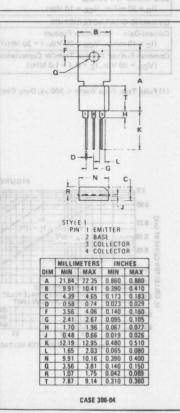


### MAXIMUM RATINGS

Rating	Symbol	BF460	BF461	BF462	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	VCBO	250	300	350	Vdc
Emitter-Base Voltage	VEBO	4	6.0	-	Vdc
Collector Current - Continuous Peak	¹c	ICS	0.5 0.7	дидио	Adc
Base Current	IB	Switz	250 —	e dion s	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	4	2.0 16		Watts mW/OC
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	-	10 80		Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	als grids	-55 to +15	50	°C
Solder Temperature, 1/16" from Case for 10 Seconds	rseng <del>-</del> r ba ad ai 1 ens	iste of Fi	260 —		°C

### THERMAL CHARACTERISTICS

Characteristic supply of step a	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	ReJC	12.5	oc/M



3

MOTOROLA

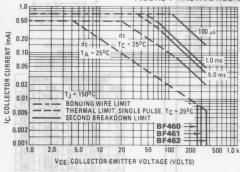


Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)  BF460 BF461 BF462		BVCEO	250 300 350	_ _ _	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0) BF460 BF461 BF462	топе	BVCBO	250 300 350	NPN IH VOLTAG	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)	ations circuits.	BVEBO	6.0	ed for high-ya	Vdc
Collector Cutoff Current (VCB = 150 Vdc, IE = 0) BF460 (VCB = 200 Vdc, IE = 0) BF461 (VCB = 250 Vdc, IE = 0) BF462	r regulators.	ICBO	iers, and high-i	0.2 0.2 0.2 0.2	μAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	162	EBO D	(Min) = 10 = 1	obv (0.1 = 03	μAdc
ON CHARACTERISTICS(1)		NEAN OF	- ALS (NOTE)	Shirt of Files	noly
DC Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		hFE	25 40	0 828 8 1075 miles	O wo.∫ ≤ cob
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc) (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 5 mAdc)		VCE(sat)	saigestien @ T <sub>j</sub>	0.6	
Base-Emitter On Voltage (IC = 30 mAdc, VCE = 10 Vdc)		V <sub>BE</sub> (on)	Date Park 18	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (IC = 10 mAdc, VCE = 20 Vdc, f = 20 MHz)		fT	45	200	MHz
Common-Emitter Reverse Transfer Capacitance (VCB = 20 Vdc, IE = 0, f = 1.0 MHz)		Cre	-	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

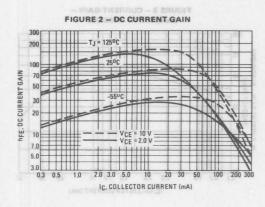
### TYPICAL CHARACTERISTICS

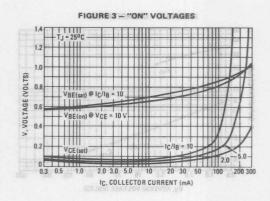
### FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA

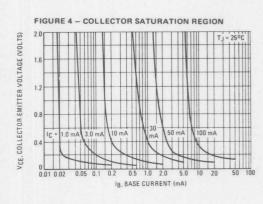


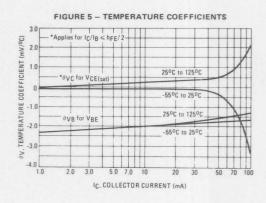
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

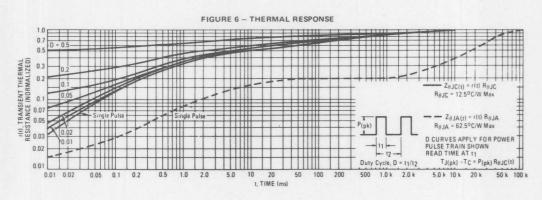
The data of Figure 1 is based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

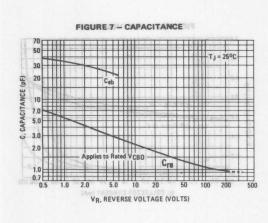


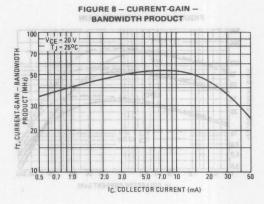


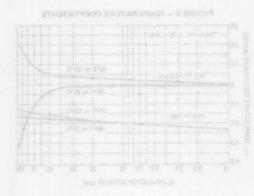


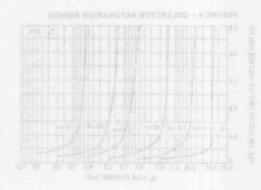


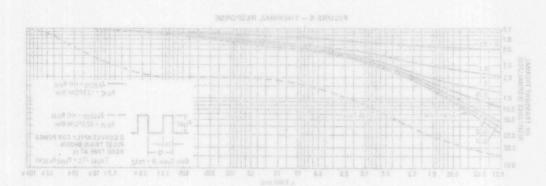








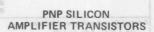


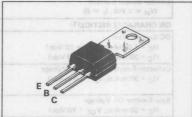


# PNP SILICON ANNULAR\* HIGH VOLTAGE AMPLIFIER TRANSISTORS

... designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage BVCEO = 350 Vdc (Min) @ IC = 1.0 mAdc — BF465
- Low Collector Emitter Saturation Voltage –
   VCE(sat) = 0.75V (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance –
   C<sub>re</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 60 Vdc
- Duowatt Package —
   2 Watts Free Air Dissipation @ TA = 25°C
- Complementary to NPN BF460/BF461/BF462



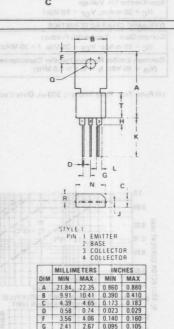


### MAXIMUM BATINGS

Rating	Symbol	BF463	BF464	BF465	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	VCBO	250	300	350	Vdc
Emitter-Base Voltage	VEBO	4	5 V -	-	Vdc
Collector Current - Continuous Peak	¹c	4	0.5 0.7	ARANO	Adc
Base Current	1 <sub>B</sub>	-	<del> 250</del>	-	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	4	2.0 16		Watts mW/OC
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	976 S	10 80		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	rdo ad yzi	-55 to +15	60 -	°C
Solder Temperature, 1/16" from Case	ns qua say la er Tenig	data of F	260		°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W



	MILETIN	FIFTIG	HIGHTLE		
MIG	MIN	MAX	MIN	MAX	
A	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
Н	1.70	1.96	0.067	0.07.7	
J	0.48	0.66	0.019	0.026	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
0	3.56	3.81	0.140	0.150	
R	1.07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

CASE 306-04

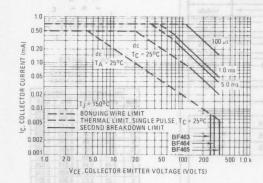


### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0) BF463 BF464 BF465		BVCEO	250 300 350	-	Vdc
Collector-Base Breakdown Voltage (IC = 100 µAdc, IE = 0) BF463 BF464 BF465	згояз	BVCBO	250 300 350	PNP CH VÖLTA	Vdc
Emitter-Base Breakdown Voltage $(I_E = 100 \mu Adc, I_C = 0)$		BVEBO	5	-	Vdc
Collector Cutoff Current (VCB = 150 Vdc, IE = 0) BF463 (VCB = 200 Vdc, IE = 0) BF464 (VCB = 250 Vdc, IE = 0) BF465	or regulators.	СВО	Clers, and high	0.2 0.2 0.2 0.2	μAdc
Emitter Cutoff Current (V <sub>BE</sub> = 3 Vdc, I <sub>C</sub> = 0)	466	IEBO		0.1 6 V 0 E = 0 3 1	μAdc
ON CHARACTERISTICS(1)		- sgallo	r Saturation V	allector-Emitte	O Wall 6
DC Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		hFE		7 6268 — 7 9 10 (a M) 180 E —	o Low C
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc)		VCE(sat)	T Ø nollsgizzi	505X159 111 1 10 0.75 Air E	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		VBE(on)	РК 450/2F	0.85	QmgQ Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (IC = 10 mAdc, VCE = 20 Vdc, f = 20 MHz)		fT	45	200	MH2
Common Emitter Reverse Transfer Capacitance (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)		Cre		3.0	pF

(1) Pulse Test: Pulse Width < 300 us, Duty Cycle > 2.0%

### TYPICAL CHARACTERISTICS



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate

The data of Figure 1 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$  provided  $T_{J(pk)} \le 150^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA

3

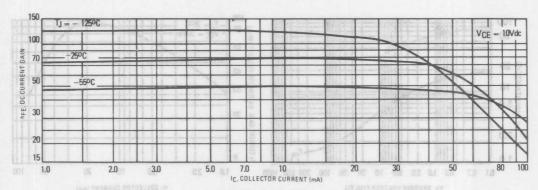


FIGURE 2 - DC CURRENT GAIN

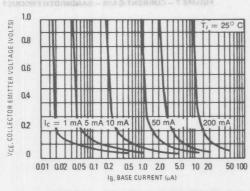


FIGURE 3 — COLLECTOR SATURATION REGION

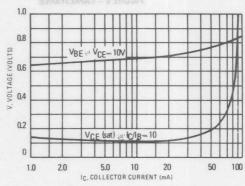


FIGURE 4 - "ON" VOLTAGES

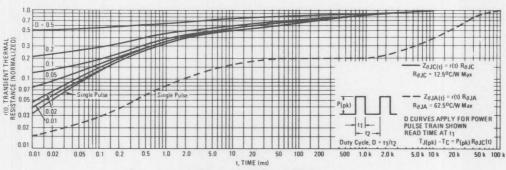
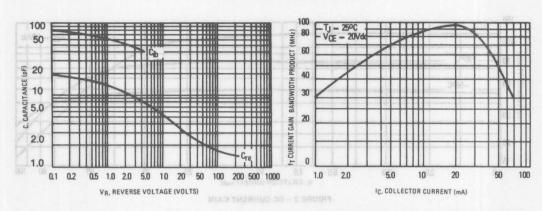
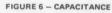


FIGURE 5 - THERMAL RESPONSE

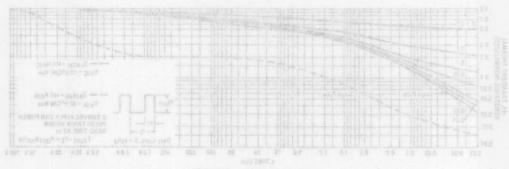






### FIGURE 7 - CURRENT-GAIN - BANDWIDTH PRODUCT





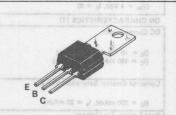
# NPN SILICON ANNULAR ♦ HIGH VOLTAGE AMPLIFER TRANSISTORS

... designed for horizontal driver applications in television receivers.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 250 Vdc (min) @ IC = 1.0 mAdc BF468
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.5 Vdc (max) @ IC = 200 mAdc
- Duowatt Package –
   2 Watts Free Air Dissipation @ TA = 25 °C



TRICAL CHARACTERISTICS (TA . 25°C ontes otherwise

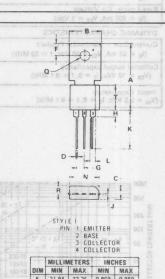


### MAXIMUM RATINGS

Rating	Symbol	BF466	BF467	BF468	Unit
Collector-Emitter Voltage	VCEO	150	200	250	Vdc
Collector-Base Voltage	VCBO	150	200	250	Vdc
Emitter-Base Voltage	VEBO	-	5		Vdc
Collector Current — Continuous Peak	ıc	-	1		Adc
Base Current	1 <sub>B</sub>	-	<u> </u>		mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	-	2.0 16	=:	Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	e une leve	10 80		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	rie gritzeni cdo od rze	55 to +15	50	°C
Solder Temperature, 1/16" from Case for 10 Seconds	ted to great june 1 is ba		260 —		°c

### THERMAL CHARACTERISTICS

Characteristic Pupil at a set	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	62.5	°C/W
Thermal Resistance, Junction to Case	ROJC	12.5	°C/W



DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
B	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
0	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
H	1.70	1.96	0.067	0.07.7
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

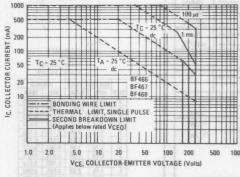
CASE 306-04

3

FIGURE 1 - ACTIVE-REGION SAFE OF ERATING AREA



Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)  BF466 BF467 BF468		BVCEO	150 200 250	<u>-</u>	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0) BF466 BF467 BF468		BVCBO	150 200 250	- - 14914 -	Vdc
(IE = 100 µAdc, IC = 0)	EROTE	BVEBO	5	DATJOY HOL	Vdc
Collector Cutoff Current (VCB = 100, Vdc, IE = 0) BF466 (VCB = 150, Vdc, IE = 0) BF467 (VCB = 200, Vdc, IE = 0) BF468	levision receivers.	ICBO	al driver applic	0.1 0.1 0.1	μAdc
mitter Cutoff Current		1EBO	-	0.1	/¿Adc
$(V_{BE} = 4 \text{ Vdc}, I_C = 0)$					
ON CHARACTERISTICS (1)	The second	- agmin	V HWOONESTE T	distribution of the	OU VIDIET IN
DC Current Gain $ \begin{aligned} &(I_C = 10 \text{ mA, } V_{CE} = 10 \text{ Vdc}) \\ &(I_C = 100 \text{ mA, } V_{CE} = 10 \text{ Vdc}) \end{aligned} $		hFE - math		Rector-Émitte () = 1.6-Vdc (r t Package —	VCE(sa
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 200 mAdc, I <sub>8</sub> = 20 mAdc)		VCE(sat)	= AT @ neusec	1.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 200 mA, V <sub>CE</sub> = 1 Vdc)		VBE(on)		1	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product $(I_C = 50 \text{ mA}, V_{CE} = 20 \text{ Vdc}, f = 20 \text{ MHz})$		fΤ	100		MHz
Collector output capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)		Cob	-	12	pF
Input Capacitance (Var = 0.5 Vdc, I <sub>C</sub> = 0, f = 0.1 MHz)		Cip	-	110	р <b>F</b>

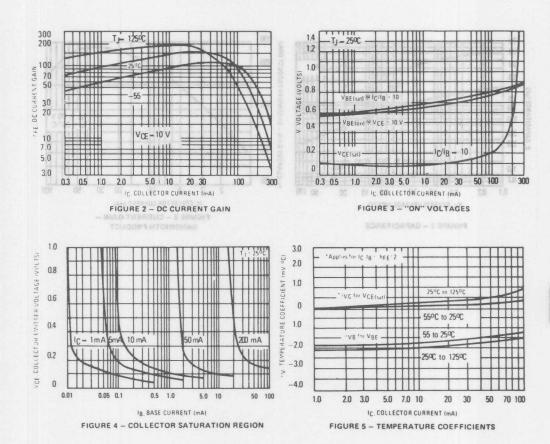


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on  $T_{J(pk)}=150^{\circ}\text{C}$ ,  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA

### TYPICAL CHARACTERISTICS



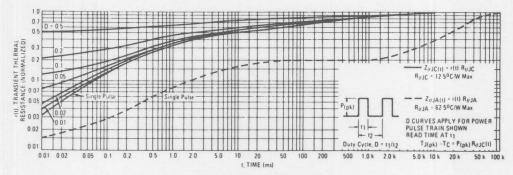
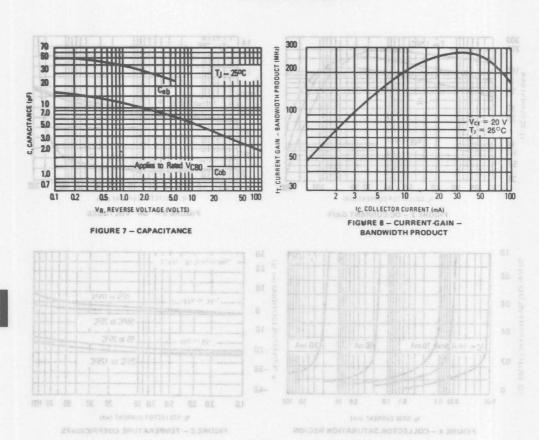
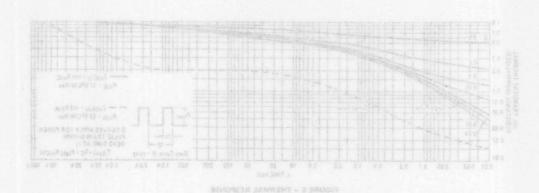


FIGURE 6 - THERMAL RESPONSE





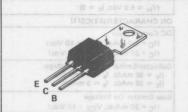


### NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFER TRANSISTORS

. . designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage -BVCFO = 350 Vdc (Min) @ IC = 1.0 mAdc - BF759
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 0.6 Vdc (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance -C<sub>re</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 20 Vdc
- Duowatt Package -2 Watts Free Air Dissipation @ TA = 25°C
- Complements to NPN BF760/BF761/BF762







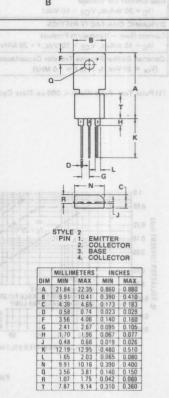
Rating	Symbol	BF757	BF758	BF759	Unit
*Collector-Emitter Voltage	VCEO	250	300	350	Vdc
*Collector-Base Voltage	VCBO	250	300	350	Vdc
*Emitter-Base Voltage	VEBO	4	- 6.0 -	-	Vdc
*Collector Current - Continuous Peak	¹c	- 201	0.5 0.7	AHAHO	Adc
*Base Current	IB	-	250	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	-	2.0 16		Watts mW/OC
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	C 107 200 d	10 80		Watts mW/ <sup>o</sup> C
*Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	er <u>a goldo.</u> Edo sa 18	-55 to +15	50	°C
*Solder Temperature, 1/16" from Case for 10 Seconds	da Faug	1 To each	260 —	-	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

TO 1 - ACTIVE REGION SAFE OFFRATING AREA

3-479



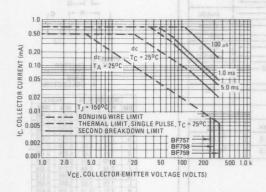
CASE 306-04

### \*ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0) BF757 BF758 BF759		BVCEO	250 300 350	-	Vdc
Collector-Base Breakdown Voltage  (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)  BF757  BF758  BF759	TORIS	BVCBO	250 300 350	TTOA_HOHH	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)		BVEBO	6.0		Vdc
Collector Cutoff Current (VCB = 150 Vdc, IE = 0) BF757 (VCB = 200 Vdc, IE = 0) BF758 (VCB = 250 Vdc, IE = 0) BF759	ir regulators.	СВО	iers, and high a	0.2 0.2 0.2 0.2	μAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	087	IEBO		0.1 Jane 10 1 Jane 10	
ON CHARACTERISTICS(1)		- lage -	Saturation Vo	illector-Emitter	- Low Co
DC Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		hFE m GS	25	3 eas 8— ercelle xalv 180	
Collector-Emitter Saturation Voltage $(I_C=30 \text{ mAdc}, I_8=3.0 \text{ mAdc})$ $(I_C=50 \text{ mAdc}, I_8=5 \text{ mAdc})$		VCE(sat)	T @ nortagiza	0.6 1.5 1 mg	
Base-Emitter On Voltage (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		VBE(on)	BF760/BF761	4914 <b>1.0</b> 18m	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 20 Vdc, f = 20 MHz)		fT	45	200	MHz
Common Emitter Reverse Transfer Capacitance ( $V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz}$ )		Cre	-	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

### TYPICAL CHARACTERISTICS

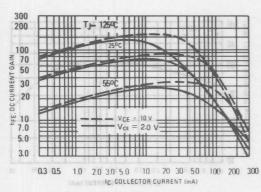


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on  $T_{J(pk)}=150^{0}\mathrm{C}$ :  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} {\stackrel{\leqslant}{\otimes}} 150^{0}\mathrm{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA

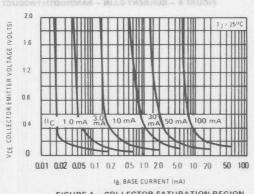
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TJ - 25°C 12 1.0 0.3 0.5 0.4 0.3 0.5 1.0 2.0 3.0 5.0 10 20 30 50 100 200 300 IC. COLLECTOR CURRENT (mA)

FIGURE 2 - DC CURRENT GAIN

FIGURE 3 - "ON" VOLTAGES



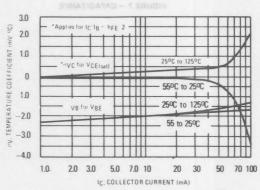


FIGURE 4 - COLLECTOR SATURATION REGION

FIGURE 5 - TEMPERATURE COEFFICIENTS

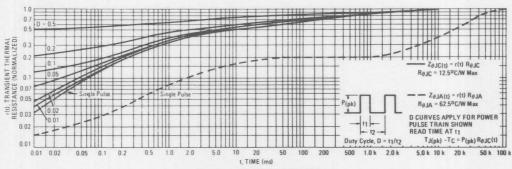
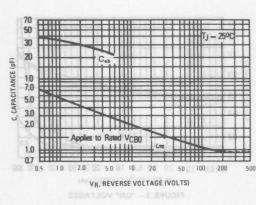


FIGURE 6 - THERMAL RESPONSE



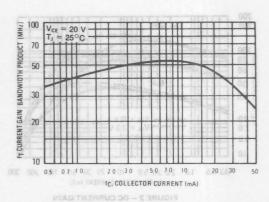
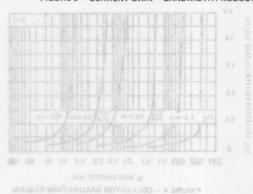
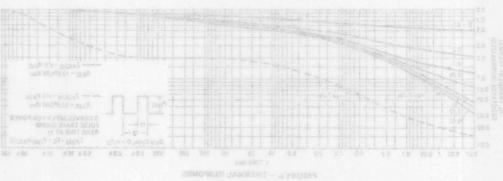


FIGURE 7 - CAPACITANCE



FIGURE 8 - CURRENT-GAIN - BANDWIDTH PRODUCT





3-482

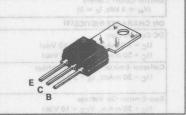


# PNP SILICON ANNULAR\* HIGH VOLTAGE AMPLIFIER TRANSISTORS

. designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 350 Vdc (Min) @ iC = 1.0 mAdc BF762
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.75V (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance –
   C<sub>re</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 60 Vdc
- Duowatt Package –
   2 Watts Free Air Dissipation @ TA = 25°C
- Complementary to NPN BF757/BF758/BF759



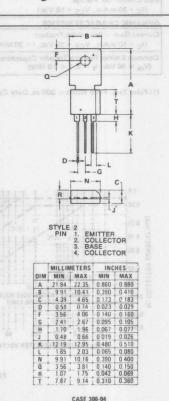


### MAXIMUM RATINGS

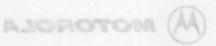
MAXIMON HATINGO					
Rating	Symbol	BF760	BF761	BF762	Unit
*Collector-Emitter Voltage	VCEO	250	300	350	У́dс
*Collector-Base Voltage	VCBO	250	300	350	Vdc
*Emitter-Base Voltage	VEBO	-	5 -		Vdc
*Collector Current - Continuous Peak	lc		0.5 — — 0.7 —		Adc
*Base Current	IB	-	250	-	mAdc
*Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	4	2.0 16	=:	Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	DIVERSITE OF	10 80		Watts mW/ <sup>O</sup> C
*Operating and Storage Junction Temperature Range			-55 to +15	50	°C
*Solder Temperature, 1/16" from Case for 10 Seconds	Baile III par	Section and I	260		°C

### THERMAL CHARACTERISTICS

Characteristic Musica Maria	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Thermal Resistance, Junction to Case	ReJC	2) 12.5	°C/W



FE 1 - ACTIVE REGION SAFE OPERATING AREA

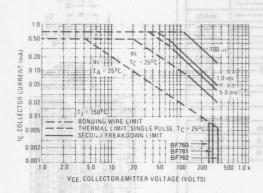


### \*ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0) BF760 BF761 BF762		BVCEO	250 300 350		Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0) BF760 BF761 BF762	28013	BVCBO	250 300 350	PM4 CH VOLTAX	Vdc
Emitter-Base Breakdown Voltage (IE = 100 µAdc, IC = 0)	eticases tuestes	BVEBO	5 solvy VT apeth	- ou doin not be:	Vdc
Collector Cutoff Current (VCB = 150 Vdc, IE = 0) BF760 (VCB = 200 Vdc, IE = 0) BF761 (VCB = 250 Vdc, IE = 0) BF762	or regulators.	СВО	hers, and high	0.2 0.2 0.2 0.2	μAdo
Emitter Cutoff Current (V <sub>BE</sub> = 3 Vdc, I <sub>C</sub> = 0)	297	IEBO O	= 21 (0) (41(14)	BV 00.1	μAdc
ON CHARACTERISTICS(1)		- afam.	A modernies i	8711072-10739310	D WOJ W
DC Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		hFE		) -ee 8-2-01-000 (aM) 180) Z =	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc)		VCE(sat)	T @ normalise	0.75	
Base-Emitter On Voltage (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		VBE(on)	PHE BETST/BET	0.85	Igmo Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product (IC = 10 mAdc, VCE = 20 Vdc, f = 20 MHz)		fT	45	200	MHz
Common Emitter Reverse Transfer Capacitance (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)		Cre	-	3	pF

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

TYPICAL CHARACTERISTICS



There are two limitations on the power handling ability of a transistor—average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

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FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA

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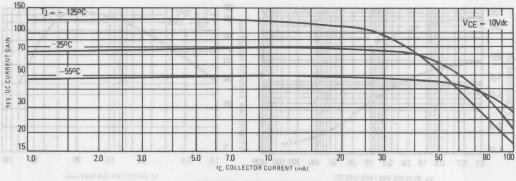


FIGURE 2 - DC CURRENT GAIN

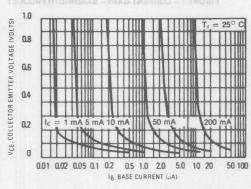


FIGURE 3 - COLLECTOR SATURATION REGION

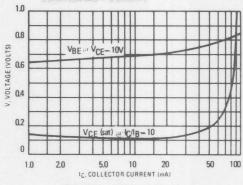


FIGURE 4 - "ON" VOLTAGES

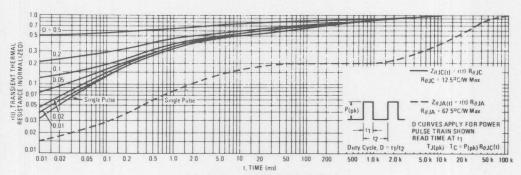


FIGURE 5 - THERMAL RESPONSE

3

TYPICAL CHARACTERISTICS (continued)

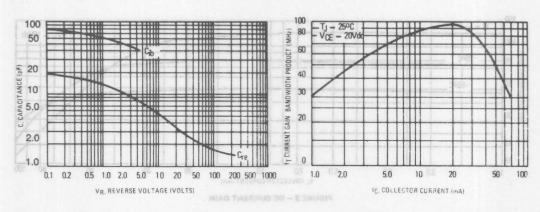
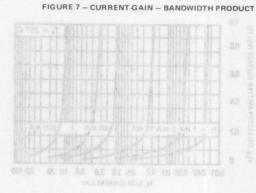
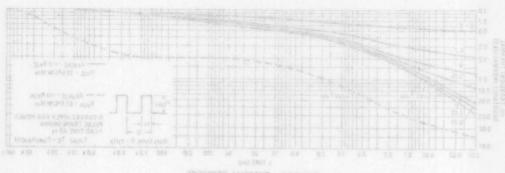


FIGURE 6 - CAPACITANCE





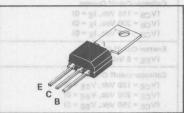


... electrically Low CRE identical in Duowatt package to BF469/470, and BF471/472 Case 77.

Designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage —
   BVCEO = 350 Vdc (Min) @ IC = 1.0 mAdc BF789/792.
- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 1.0 V (Max) @ IC = 10 mAdc.
- Low Collector Base Capacitance —
   Cre = 1.8 pF (Max) @ VCB = 30 Vdc.
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25 °C.

# COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS

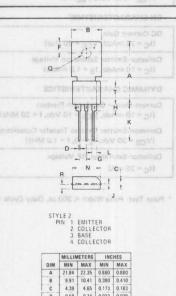


### MAXIMUM RATINGS

Ratings	Symbol	BF787 BF790	BF788 BF791	BF789 BF792	Unit
Collector-Emitter Voltage	VCEO	250	300	350	Vdc
Collector-Base Voltage	VCBO	250	300	350	Vdc
Collector Current — Continuous Peak	lc lc		0.1		Adc
Total Power Dissipation @ T <sub>A</sub> = 25 °C Derate above 25 °C	PD		2.0		Watts mW/° C
Total Power Dissipation @ T <sub>C</sub> = 25 °C Derate above 25 °C	PD		10 40		Watts mW/° C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-!	55 to +1!	50	°C
Solder Temperature, 1/16" from Case for 10 Seconds	-		260		°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit	
Thermal Resistance, Junction to Ambient	$R_{\theta}JA$	62.5	°C/W	
Thermal Resistance, Junction to Case	$R_{\theta}JC$	25	°C/W	



0.58 0.74 0.023 0.029 3.56 4.06 0.140 0.160 2.41 2.67 0.095 0.105 1.70 1.96 0.067 0.077 0.48 0.66 0.019 0.026 12.19 12.95 0.480 0.510

2.03 0.065 0.080

10.16 0.390 0.400 3.81 0.140 0.150 1.75 0.041 0.069 9.14 0.310 0.360

1.65

9.91 3.56

> 7.87 9.14 0.: CASE 306-04



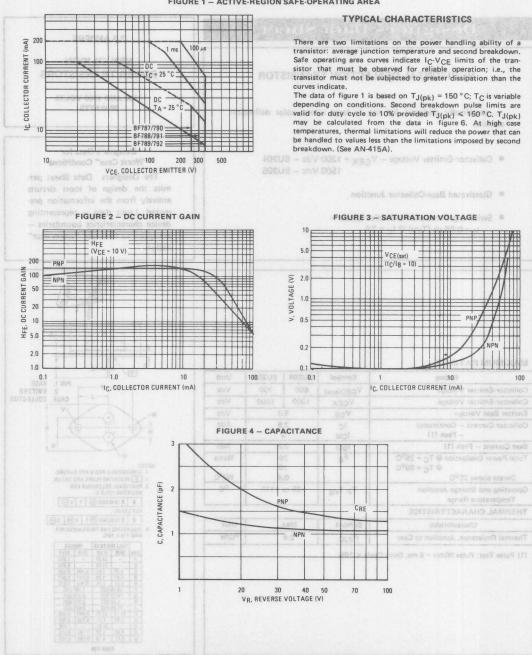


### ELECTRICAL CHARACTERISTICS (TA = 25 °C unless otherwise noted)

Characteristic					Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS								
Collector-Emitter Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BF787/790 BF788/791 BF789/792		BVCEO	250 300	IE ATJOV HI	Vdc		
Collector-Base Breakdown Voltage (I <sub>C</sub> = 10 μAdc, I <sub>E</sub> = 0)	BF787/790 BF788/791 BF789/792			BVCBO	250			
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 µAdc, I <sub>C</sub> = 0)	roma output circuits,				BVEBO	abir VI equ d bns a 5 dili		Vdc
Collector-Cutoff Current (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 200 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 250 Vdc, I <sub>E</sub> = 0)	BF787/790 BF788/791 BF789/792			СВО	ter Breckdow to (Min) & Ic	0.2	μAdc	
Emitter-Cutoff Current (VBE = 5 Vdc, I <sub>C</sub> = 0)				IEBO	5 ⊕ (x±M)	10	μAdc	
Collector-cutoff Current (V <sub>CE</sub> = 150 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 200 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 250 Vdc, V <sub>BE</sub> = 0)	BF787/790 BF788/791 BF789/792			ICES	000	10 10 10	μAdc	
ON CHARACTERISTICS1								
DC Current Gain (I <sub>C</sub> = 25 mAdc, V <sub>CE</sub> = 20 Vdc)					hFE	50		
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 1.0 mAdc)					VCE(sat	)	zámir)	Vdc
DYNAMIC CHARACTERISTICS		GAT HO	lastan!	52520				
Current-Gain — Gandwidth Product (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 10 Vdc, f = 20 MHz)	DOV	350	300	8F796 250	f <sub>T</sub>	60	agentaV vs	MHz
Common-Emitter Reverse Transfer Capacitance (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)					C <sub>re</sub>		1.8	PF Pastinotestic
Collector-Saturation RF Voltage (I <sub>C</sub> = 25 mA)	20/4		0.2		VCE(sat)		pical 20	V
[ [man] ]	O Wim		16				0.9	Decate above
Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2	.0%.						of 9 nation 6 To	
							Decrating and S Temperature F	
Cont.   Cont							HERMAL CI	
00 ALF 2016 0 000 0 000	covistic Symbol Max Unit			Cheracteristic	rentO			
								Insuringi Registan

MOTOROLA

FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA





### Designers Data Sheet

### HORIZONTAL DEFLECTION TRANSISTOR

... specifically designed for use in large screen color deflection circuits.

- Collector-Emitter Voltage V<sub>CEX</sub> = 1300 Vdc BU204 1500 Vdc - BU205
- Glassivated Base-Collector Junction
- Switching Times with Inductive Loads t<sub>f</sub> = 0.65 μs (Typ) @ I<sub>C</sub> = 2A

2.5 AMPERE

# NPN SILICON POWER TRANSISTORS

1300 AND 1500 VOLTS 36 WATTS

# Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

3

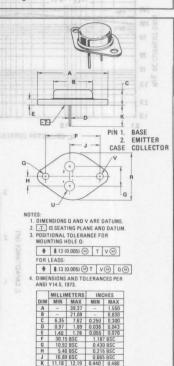
### MAXIMUM RATINGS

Million Committee of the Committee of th					
951 Rating	Symbol	BU204	BU205	Unit	
Collector-Emitter Voltage	VCEO(sus)	600	700	Vdc	
Collector-Emitter Voltage	VCEX	1300	1500	Vdc	
Emitter Base Voltage	VEB	5	.0	Vdc	
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	DMATID	.5	Adc	
Base Current - Peak (1)	IBM	2	.5	Adc	
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 90°C Derate above 25°C	PD	1	6 0 .4	Watts W/°C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+115	°C	

THERMAL	CHARACT	ERISTICS	

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	2.5	°C/W	

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle < 10%.

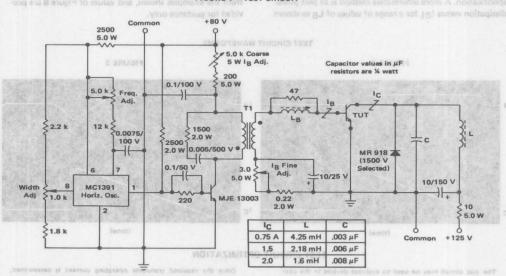


### ELECTRICAL CHARACTERISTICS (To = 250 unless otherwise noted )

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)	i enti	to onare ant o	allognoo	the concept of	lwan 48
Collector-Emitter Sustaining Voltage BU204 (IC = 100 mAdc, I <sub>B</sub> = 0) BU205	V <sub>CEO</sub> (sus)	600 700	dely abosp The prob	in curriet is wi beliestic <del>a</del> design	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 1300 Vdc, V <sub>BE</sub> = 0) BU204 (V <sub>CE</sub> = 1500 Vdc, V <sub>BE</sub> = 0) BU205	ICES	of device, prior empired by pro- ty the Teaset of	This to act	1.0 d 1.0	mAdc
Emitter Base Voltage (I E = 10 mA, I C = 0)	VEBO	5.0	and of soc	ice hpg at the	V dc
ON CHARACTERISTICS (1)		and Alexand Hill	to roseniza	to be a constant of	of making
Collector-Emitter Saturation Voltage (IC = 2.0 Adc, IB = 1.0 Adc)	VCE(sat)	is driven by a v	totalenare	5.0	Vdc
Base Emitter Saturation Voltage	V <sub>BE</sub> (sat)	as content with 2. This result	ummon a in Figur	1.5	Vdc
Second Breakdown Collector Current with Base	I <sub>S/B</sub>	ors, because exi-	See I	igure 14	st, but riers bed
DYNAMIC CHARACTERISTICS VOLUME STATES OF THE	1 -60	nis is a high dissi	ductive, 11	nsistor is still con	s u entr t
Current-Gain — Bandwidth Product (1) (IC =0.1 Adc, VCE = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	fr .Vii	rising wirk rapil inductance to	4.0	since the collect m is overcome	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 1.0 MHz)	C <sub>ob</sub>	iwode a <del>n</del> faziew ni nobsenideren	50	to slow-the bes	riuopE a
SWITCHING CHARACTERISTICS	0	ent is still flow	thup seed t	goose while the	or norsel
Fall Time (I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 1.0 Adc, L <sub>B</sub> = 25 μH) (See Figure 1)	tf 950	e empi <del>ri</del> cally, si	0.65	the right Lg is a	μs

(1) Pulse Test: Pulse Width < 300 μs, Duty Cycle = 2%.

## ness ad neo as , (solding ylesuloade ene jejl ton el rediciól and a



### DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A-05-1/4" laminate "E" iron core. Primary Inductance – 39 mH. Secondary Inductance – 22 mH, Leakage Inductance with primary shorted – 2.0 μH, Primary 260 turns #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

### **BASE DRIVE: The Key to Performance**

By now, the concept of controlling the shape of the turn-off base current is widely accepted and applied in horizontal deflection design. The problem stems from the fact that good saturation of the output device, prior to turn-off, must be assured. This is accomplished by providing more than enough  $I_{B1}$  to satisfy the lowest gain output device  $h_{FE}$  at the end of scan  $I_{CM}.$  Worst case component variations and maximum high voltage loading must also be taken into account.

If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Figure 2. This results in rapid, but only partial, collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Figure 3, thus allowing excess carrier recombination in the collector to occur while the base current is still flowing.

Choosing the right LB is usually done empirically, since the equivalent circuit is complex, and since there are several important variables (ICM, IB1, and hFE at ICM). One method is to plot fall time as a function of LB, at the desired conditions, for several devices within the hFE specification. A more informative method is to plot power dissipation versus IB1 for a range of values of LB as shown

in Figures 4 and 5. This shows the parameter that really matters, dissipation, whether caused by switching or by saturation. The negative slope of these curves at the left (low IB1) is caused by saturation losses. The positive slope portion at higher IB1, and low values of LB is due to switching losses as described above. Note that for very low LB a very narrow optimum is obtained. This occurs when IB1 hFE = ICM, and therefore would be acceptable only for the "typical" device with constant ICM. As LB is increased, the curves become broader and flatter above the IB1 hFE = ICM point as the turn-off "tails" are brought under control. Eventually, if LB is raised too far, the dissipation all across the curve will rise, due to poor initiation of switching rather than tailing. Plotting this type of curve family for devices of different her, essentially moves the curves to the left or right according to the relation IB1 hFE = constant. It then becomes obvious that, for a specified ICM, an LB can be chosen which will give low dissipation over a range of hFE and/or IB1. The only remaining decision is to pick IR1 high enough to accommodate the lowest hfe part specified. Figure 8 gives values recommended for LB and IB1 for this device over a wide range of ICM. These values were chosen from a large number of curves like Figure 4 and Figure 5. Neither LB nor IB1 are absolutely critical, as can be seen from the examples shown, and values of Figure 8 are provided for guidance only.

### **TEST CIRCUIT WAVEFORMS**

# FIGURE 2 TO TOTAL STATE OF THE STATE OF THE

# (time)

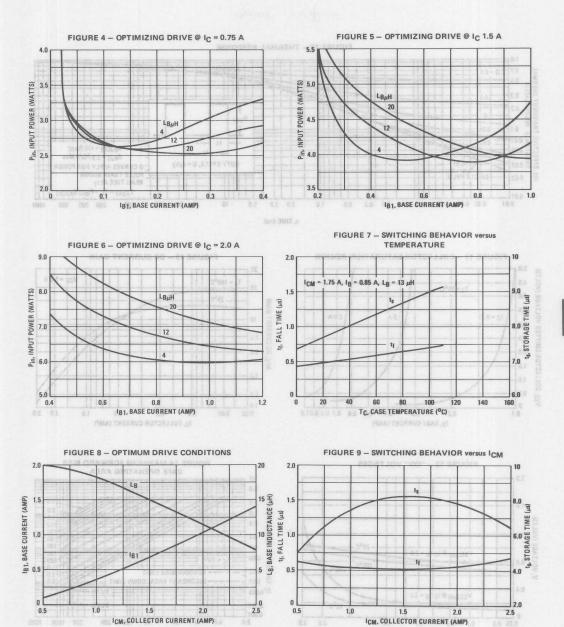
FIGURE 3

### **TEST CIRCUIT OPTIMIZATION**

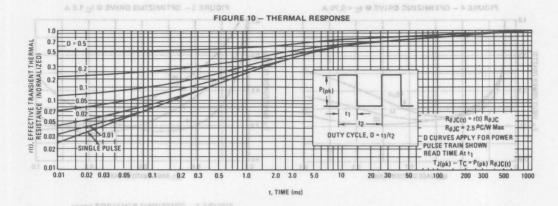
The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transitor that is of fundamental importance.

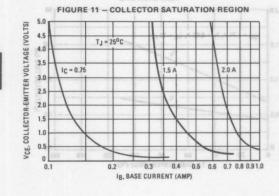
Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

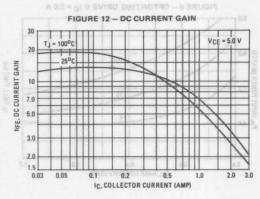
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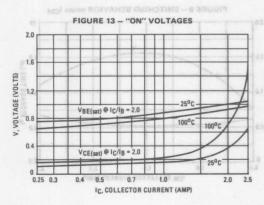


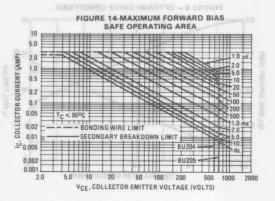














# Designers Data Sheet

#### HORIZONTAL DEFLECTION TRANSISTOR

... specifically designed for use in large screen color deflection circuits.

- Collector-Emitter Voltage VCEX = 1300 Vdc - BU207 1500 Vdc - BU208
- Collector-Emitter Sustaining Voltage VCEO(sus) = 600 Vdc - BU207 700 Vdc - BU208
- Switching Times with Inductive Loads, t<sub>f</sub> = 0.4 μs (Typ) @ Ic = 4.5 A
- Optimum Drive Condition Curves
- Glass Base-Collector Junction

# \*MAXIMUM RATINGS

Rating	Symbol	BU207	BU208	Unit
Collector-Emitter Voltage	VCEO(sus)	600	700	Vdc
Collector-Emitter Voltage	VCEX	1300	1500	Vdc
Emitter Base Voltage	VEB		517	Vdc
Collector Current - Continuous Peak (1)	IC ICM		5	Adc
Base Current - Peak (1)	IBM		4	Adc
Total Power Dissipation @ T <sub>C</sub> = 95°C Derate above 95°C	PD to A gi	1 3	2.5	Watts W/OC
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to	+115	°C
THERMAL CHARACTERISTICS				V

THERMAL CHARACTERISTICS			
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	RHJC	1.6	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

Primary Inductance — 35 mH, Secondary Induceance — 0.22 mH.

Leakage Inductance with primary shorted — 2.0 pH. Primary 260

Leakage Inductance with primary shorted — 2.0 pH. Primary 260

Lutra, #28 AWG enamel wite, Secondary 17 surns, #22 AWG

erranel wite.

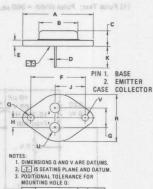
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle < 10%.

5 AMPERE TOTAL TOTAL NPN SILICON POWER TRANSISTORS 1300 AND 1500 VOLTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design.





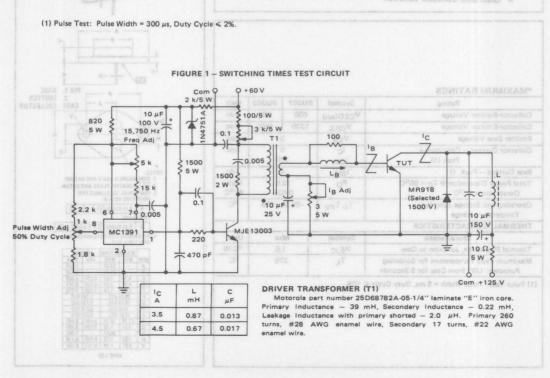
- ♦ 0.13 (0.005) M T V M
- ♦ 0.13 (0.005) @ T V @ Q @ 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIN	METERS	INC	HES		
DIM	MIN	MAX	MIN	MAX		
A	-	39.37	-	1,550		
В	3-	21.08	-	0.830		
C	6.35	7.62	0.250	0,300		
D	0.97	1.09	0.038	0.043		
E	1.40	1.78	0.055	0.070		
F	30,15	30,15 BSC		1.187 BSC		
G	10.92	10.92 BSC		0.430 BSC		
H	5.48	BSC	0.215 BSC			
J	16.89	BSC	0.665 BSC			
K	11.18	12.19	0.440	0.480		
0	3.81	4.19	0.150	0.165		
R	-	26.67	-	1,050		
U	4.83	5.33	0.190	0.210		
٧	3.81	4.19	0.150	0.165		

SWITCHING TIMES TEST CIRCUIT



Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)		ENGLISH.					E-
Collector-Emitter Sustaining Voltage	BU207	***************************************	VCEO(sus)	600		_	Vdc
(I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BU208			700	TO SEE THE	時期 元じから	THE REAL PROPERTY.
Collector Cutoff Current			ICES				mAdc
(V <sub>CE</sub> = 1300 Vdc, V <sub>BE</sub> = 0)	BU207	-			-	1.0	
(V <sub>CE</sub> = 1500 Vdc, V <sub>BE</sub> = 0)	BU208			-		1.0	
Emitter Base Voltage (I <sub>E</sub> = 10 mA, I <sub>C</sub> = 0)			VEBO	5.0	7 -	-	Vdc
ON CHARACTERISTICS (1)		何	CTRISHAL	CTION YO	S IERO I	STMOSH	HON
DC Current Gain (IC = 4.5 Adc, VCE = 5 Vdc)			PEE	2.25	-	-	-
Collector-Emitter Saturation Voltage (IC = 4.5 Adc, IB = 2 Adc)		noissalts	VCE(sat)	in laws so	seu aot b	10 5 VIII	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 2 Adc)	eff T		V <sub>BE</sub> (sat)	-	-	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased			I <sub>S/b</sub>			gure 14	Collecto
YNAMIC CHARACTERISTICS	nashar				d - 8U208	1500 Vd	144
Current-Gain — Bandwidth Product (IC = 0.1 Adc, VCE = 5.0 Vdc, ftee			fΤ	Tage T	4.0	Emiliar S	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MH	z)		Cob	808	125	700	pF
SWITCHING CHARACTERISTICS		9	(ditt) off bit	Loads, 14 a	BADDINDIN U	thw tomet p	Switchin
Fall Time (I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> L <sub>B</sub> = 10 μH, see			tf	- 8	0.6	i Drive Con	μs



#### BASE DRIVE: The Key to Performance

By now, the concept of controlling the shape of the turn-off base current is widely accepted and applied in horizontal deflection design. The problem stems from the fact that good saturation of the output device prior to turn-off, must be assured. This is accomplished by providing more than enough IB1 to satisfy the lowest gain output device her at the end of scan Icm. Worst-case component variations and maximum high voltage loading must also be taken into account.

If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Figure 2. This results in rapid, but only partial, collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Figure 3, thus allowing excess carrier recombination in the collector to occur while the base current is still flowing.

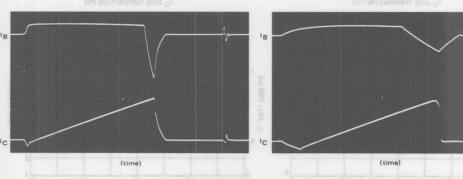
Choosing the right LR is usually done empirically, since the equivalent circuit is complex, and since there are several important variables (I<sub>CM</sub>, I<sub>B1</sub>, and h<sub>FE</sub> at I<sub>CM</sub>). One method is to plot fall time as a function of LB, at the desired conditions, for several devices within the her specification. A more informative method is to plot power dissipation versus IR1 for a range of values of LR as shown

in Figures 4 and 5. This shows the parameter that really matters, dissipation, whether caused by switching or by saturation. The negative slope of these curves at the left (low Ip1) is caused by saturation losses. The positive slope portion at higher IR1, and low values of LR is due to switching losses as described above. Note that for very low LB a very narrow optimum is obtained. This occurs when IR1 her = ICM, and therefore would be acceptable only for the "typical" device with constant ICM. As LB is increased, the curves become broader and flatter above the IR1 hee = ICM point as the turn-off "tails" are brought under control. Eventually, if LB is raised too far, the dissipation all across the curve will rise, due to poor initiation of switching rather than tailing. Plotting this type of curve family for devices of different her, essentially moves the curves to the left or right according to the relation I<sub>B1</sub> h<sub>FE</sub> = constant. It then becomes obvious that, for a specified I<sub>CM</sub>, an L<sub>B</sub> can be chosen which will give low dissipation over a range of hee and/or IB1. The only remaining decision is to pick IB1 high enough to accommodate the lowest her part specified. Figure 8 gives values recommended for LB and IB1 for this device over a wide range of ICM. These values were chosen from a large number of curves like Figure 4 and Figure 5. Neither LB nor IB1 are absolutely critical, as can be seen from the examples shown, and values of Figure 8 are provided for guidance only.

### TEST CIRCUIT WAVEFORMS



# FIGURE 3

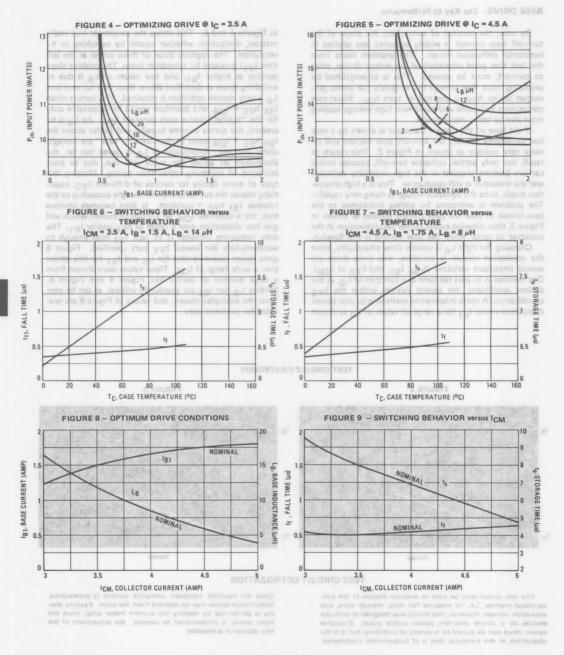


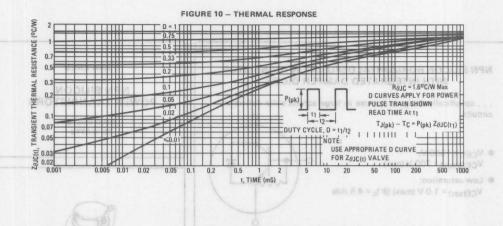
#### TEST CIRCUIT OPTIMIZATION

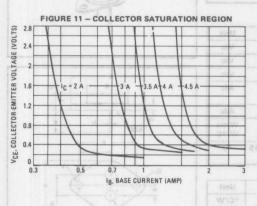
The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance.

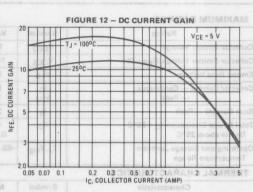
Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

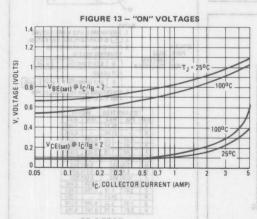




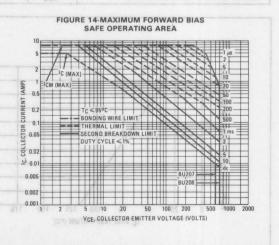








(eqyT) AA80S-OT



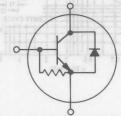
... specifically designed for use in large screen color deflection circuits

- VCES = 1500 V; VCEO(sus) = 700 V (min)
- Low saturation: VCE(sat) = 1.0 V (max) @ Ic = 4.5 Adc

# 5 AMPERES

#### **NPN SILICON POWER TRANSISTORS**

1500 VOLTS 60 WATTS

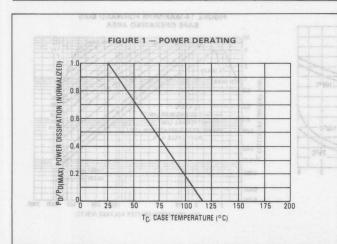


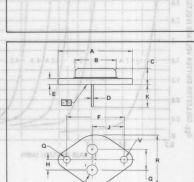
#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	700	Vdc
Collector-Emitter Voltage (RBE = 0)	VCES	1500	Vdc
Emitter Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous — Peak	I <sub>C</sub>	5.0 7.5	Adc
Base Current — Peak	I <sub>B</sub>	3.5	Adc
Total Device Dissipation T <sub>C</sub> = 25°C Derate above 25°C	PD	60 0.666	Watts W/°C
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to 115	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.5	°C/W





NOTES:

NOTES:

1. DIMENSIONS Q AND V ARE DATUMS.
2. TO IS SEATING PLANE AND DATUM.
3. POSITIONAL TOLERANCE FOR MOUNTING HOLE O:

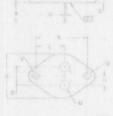
4. 0.13 (0.005) 
T V STYLE 1 3
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

FOR LEADS: ♦ 13 (0.005) W T V W Q W

4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

**CASE 1-05** TO-204AA (Type) (Formerly TO-3)

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 3%.



AGTIVE

MOTATION FOR A DESCRIPTION OF THE MOTATION OF THE MOTA



		1700	
Sollector Current - Contituous - Peak			Vác
šase Currant - Continuous - Peak (Vegativa)	gl MBl	e	
			WASTE
Operating and Storage Junction Temperature Renge			D.o.

THERMAL CHARACTERISTICS			
	Symbol .	xeM	
Maximum Lead Temperature for Soldering Purpose: 178" from Case for 6 Seconds		275	

2



# HORIZONTAL DEFLECTION TRANSISTORS

- . . . designed for use in televisions.
- Collector-Emitter Voltages VCES 1500/1700 Volts
- Fast Switching 400 ns Typical Fall Time
- Low VCE(sat) 0.3 Vdc Typical at 4.5 Adc/2.25 Adc (BU208A)
- Low thermal Resistance 1 °C/W increased reliability
- Glass passivated (patented photoglass). Triple diffused Mesa Technology for long term stability.

# 6 AND 7 AMPERES **NPN SILICON** POWER TRANSISTORS

1500 to 1700 VOLTS



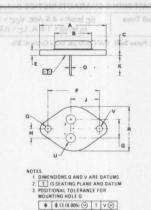
#### **MAXIMUM RATINGS**

Rating	Symbol	BU208A	BU209 BU209A	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	700	800	Vdc
Collector-Emitter Voltage	VCES	1500	1700	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	5	5	Vdc
Collector Current - Continuous - Peak	I <sub>C</sub>	7 (5) 15 (7.5)	6 (4) 12 (6)	Vdc
Base Current  - Continuous  - Peak (Negative)	I <sub>B</sub>	4 3.5		Adc
Total Power Dissipation at T <sub>C</sub> = 95°C Derate above 95°C	PD	20 (12.5) 1 (0.625)		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 to	+115	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ROJC	1.0 (1.6)	°C/W
Maximum Lead Temperature for Soldering Purpose: 1/8" from Case for 5 Seconds	TL	275	°C

- NOTE: 1. Pulsed 5 ms, Duty Cycle ≤ 10%.
  2. See page 3 for Additional Ratings on A Type.
  3. Figures in () are Standard Ratings Motorola Guarantees are Superior



FOR LEADS

| ↑ | ↑ 13 (0.005) ⊕ T | V ⊕ | 0 ⊕ DIMENSIONS AND TOLERANCES PER ANSI Y14 5, 1973

	_	-		
L. Iv	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	-	3.43	-	0.135
F	30.1	5 BSC	1.187	7 BSC
G	10.93	2 BSC	0.430	BSC
Н	5.4	6 BSC	0.21	5 BSC
J	16.89	BSC	0.66	5 BSC
K	11.18	12.19	0.440	0.480
Q	3.81	4.19	0.150	0.165
R	-	26.67	-	1.050
U	4.83	5.33	0.190	0.210
V	3.81	4.19	0.150	0.165

CASE 1-05 (TO-3)

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted)

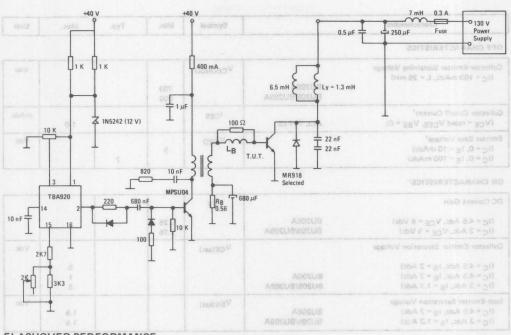
2 4 5 A 1 A 2 A 4 A 4 A 4 A 4 A 4 A 4 A 4 A 4 A 4		V 84		V.		
Characteristics	1	Symbol	Min.	Тур.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage	1	VCEO(sus)		N.E.	x	Vdc
(I <sub>C</sub> = 100 mAdc, L = 25 mH)	2					
Nm:	BU208A BU209A	-	700			
Collector Cutoff Current <sup>1</sup>		ICES	111111111111111111111111111111111111111			mAdc
(V <sub>CE</sub> = rated V <sub>CES</sub> , V <sub>BE</sub> = 0)	ALL TYPES	2 907	-	(A 21) BARSAN S	1.0	
Emitter Base Voltage <sup>1</sup>	22.0F	VEBO			175	Vdc
(I <sub>C</sub> = 0, I <sub>E</sub> = 10 mAdc)	10.55 = T = 22.06	al l	5			-
(I <sub>C</sub> = 0, I <sub>E</sub> = 100 mAdc)		318		7		
ON CHARACTERISTICS	2000 Penting	7			1 1	
DC Current Gain	30	hFE	0.000	220 880 nF	USBARY	
	DUIDOOA	00.0				1 200
(IC = 4.5 Adc, VCE = 5 Vdc)	BU208A BU209/BU209A	0	2.25	- 91	· Lull	
(I <sub>C</sub> = 3 Adc, V <sub>CE</sub> = 5 Vdc)	B0209/B0209A	++	2.25	ans		-
Collector-Emitter Saturation Voltage		VCE(sat)	-			Vdc
(I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 2 Adc)					5	-
(I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 2 Adc)	BU208A				1	17.24
(I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 1.3 Adc)	BU209/BU209A				5	141
Base-Emitter Saturation Voltage		VBE(sat)				Vdc
(I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 2 Adc)	BU208A				1.5	
(I <sub>C</sub> = 3 Adc, I <sub>B</sub> = 1.3 Adc)	BU209/BU209A				1.5	
DYNAMIC CHARACTERISTICS				FORMANCI		
Current-Gain Bandwidth Product	ditional maximum catio	be getwolfet edt	ot hegte	CYELS SOE ARD	CH8 bbs A	MHz
(IC = 0.1 Adc, VCE = 5 Vdc, f <sub>test</sub> = 1 MH:	208A BU209A(s	fT fT		4		IVIHZ
Output Capacitance Mulmissem sealud OS	AS AO	Cob			EAK	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0), f <sub>test</sub> = 1 MHz)	710 /10	30		125		bewall
SWITCHING CHARACTERISTICS	50V 1850V	31			S PEAK	YCE
Storage Time (see test circuit fig. 1)		t <sub>s</sub>				μs
$(I_C = 4.5 \text{ Adc}, I_{B1} = 1.8 \text{ Adc}, L_B = 10 \mu\text{H})$	DAITASSO DEM	ne _ c aquaia		8		m3
Fall time (see test circuit fig. 1)		tf				μs
(IC = 4.5 Adc, IB1 = 1.8 Adc, LB = 10 μH				0.4		





DYNAMIC CHARACTERISTICS

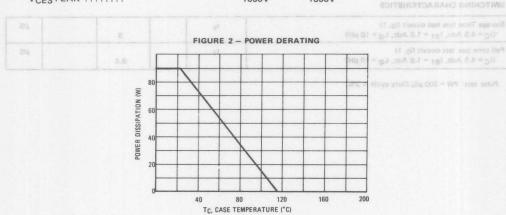
# FIGURE 1 - SWITCHING TIME TEST CIRCUIT T) 20178183TOARAHO JACHATOS J3



# FLASHOVER PERFORMANCE

The BU208A, and BU209A are guaranteed to the following additional maximum ratings

XHW.				Current-Cain Bandwidth Product
		BU208A	BU209A	(IC = 0.1 Auc. VCB = 5 Vdc, freet = 1 MHz)
IC PEAK	deO	10A	8A	20 pulses maximum of Pulse Width $\leq$ 50 $\mu$ S. Duty cycle $\leq$ 50%.
VCES PEAK		1650V	1850V	



# 3

#### BASE DRIVE The Key to Performance

By now, the concept of controlling the shape of the turn-off base current is widely accepted and applied in horizontal deflection design. The problem stems from the fact that good saturation of the output device, prior to turn-off, must be assured. This is accomplished by providing more than enough IB1 to satisfy the lowest gain output device hFE at the end of scan ICM. Worst-case component variations and maximum high voltage loading must also be taken into account.

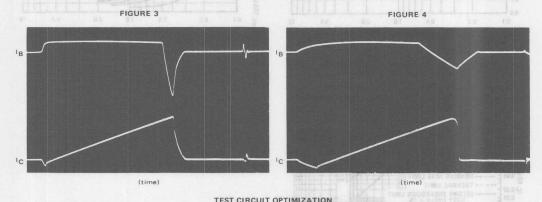
If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Fig. 3. This results in rapid, but only partial collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Fig. 4, thus allowing axcess carrier recombination in the collector to occur while the base current is still flowing.

Choosing the right LB is usually done empirically since the equivalent circuit is complex, and since there are several important variables (ICM, IB1, and hFE at ICM). One method is to plot fall time as a function of LB, at the desired conditions, for several devices within the hFE specification. A more informative method is to plot power dissipation versus IB1 for a range of values of LB.

This shows the parameter that really matters, dissipation, whether caused by switching or by saturation. For very low LB a very narrow optimum is obtained. This occurs when IB1. hFE = ICM, and therefore would be acceptable only for the "typical" device with constant ICM. As LB is increased, the curves become broader and flatter above the IB1. hFE = ICM point as the turn off "tails" are brought under control. Eventually, if LB is raised too far, the dissipation all across the curve will rise, due to poor initiation of switching rather than tailing. Plotting this type of curve family for devices of different hee, essentially moves the curves to the left, or right according to the relation IB1. hFE = constant. It then becomes obvious that, for a specified ICM, an LB can be chosen which will give low dissipation over a range of hFF and/or IB1. The only remaining decision is to pick IB1 high enough to accomodate the lowest hFE part specified. Neither LB nor IB1 are absolutely critical. Due to the high gain of Motorola devices it is suggested that in general a low value of IB1 be used to obtain optimum efficiency- eg. for BU208A with ICM = 4.5 A use JB1  $\approx$  1.5 A, at ICM = 4 A use IB1  $\approx$  1.2 A. These values are lower than for most competition devices but practical tests have showed comparable efficiency for Motorola devices even at the higher level of IR1.

An LB of 10 uH to 12 uH should give satisfactory operation of BU208A with I<sub>CM</sub> of 4 to 4.5 A and I<sub>B1</sub> between 1.2 and 2 A.

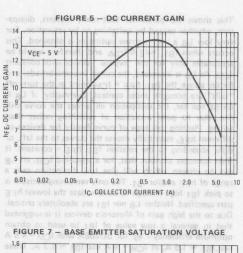
#### TEST CIRCUIT WAVEFORMS

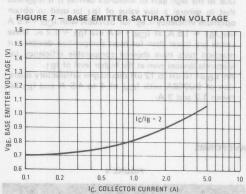


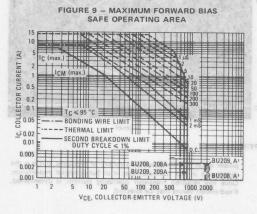
The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive

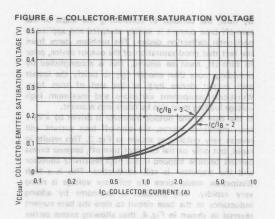
power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance. Once the required transistor operating current is determined, fixed circuit values may be selected.

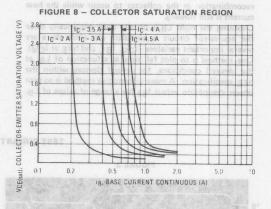
BASE DRIVE











The test circuit may be used to evaluate devices in the

<sup>&</sup>lt;sup>1</sup> Pulse width ≤ 20 μs. Duty cycle ≤ 0.25, R<sub>BE</sub> ≤ 100 Ohms.



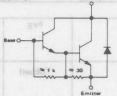
# NPN SILICON POWER DARLINGTON TRANSISTOR

The BU323, BU323A are monolithic darlington transistors designed for automotive ignition, switching regulator and motor control applications.

VCE Sat Specified at -40°C = 2 V Max. at IC = 6 A.

• 550 mJ Energy Capability Tested in Automotive Ignition Circuit.

 Photoglass Passivation for Reliability and Stability.



16 AMPERE PEAK

ELECTRICAL CHARACTERISTICS (TC = 25 °C unless otherwise noted)

# POWER TRANSISTORS **DARLINGTON NPN SILICON**

350 - 400 VOLTS 175 WATTS



Hg = 6 Ads, Ig = 120 mAds, Tg = -40 °Cl

#### MAXIMUM RATINGS

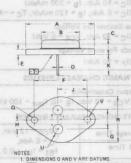
MAXIMOM NATINGS		W.SHELMER,		
2.5				
Rating	Symbol	BU323	BU323A	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Base Voltage	VCBO	500	600	Vdc
Emitter-Base Voltage	VEBO	8	8	Vdc
Collector Current — Continuous Peak (1)	lc	10 16	10 16	Adc
Base Current — Continuous	IB	3	3	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	175 100 1	175 100 1	Watts Watts W/OC
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-65 t	o +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	1	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

SIGURE 2 - SWITCHING TIMES TEST CIRCUIT



DIMENSIONS O AND V ARE DATUMS.
 T. IS SEATING PLANE AND DATUM.

POSITIONAL TOLERANCE FOR MOUNTING HOLE O ♦ \$ 13 (0.005) ⊗ T V ⊗

♦ 0.13 (0.005) @ T V @ 0 @

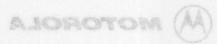
4. DIMENSIONS AND TOLERANCES PER

THURST DIRECTED

	MILLIN	METERS	INC	HES	
MIG	MIN	MAX	MIN	MAX	
A	111410	39.37	25.	1,550	
В	-	21.08	200	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	- 3.43		- 1	0.135	
F	30,15 BSC		1.187 BSC		
G	10.92	10.92 BSC		0.430 BSC	
H	5.48	SSC	0.215 BSC		
1	16.89	BSC		BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0,150	0.165	
R	- 1	26.67	Mari	1.050	
U	4.83	5.33	0.190	0.210	
V	3.81	4.19	0.150	0.165	

CASE 1-05 TO-3

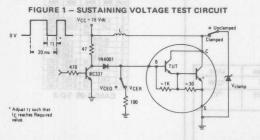
**BU323A** 



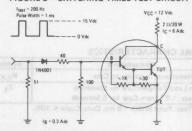
ELECTRICAL CHARACTERISTICS (TC	= 25 °C unless otherwise noted)
--------------------------------	---------------------------------

	Characteristic			Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTE	RISTICS <sup>1</sup>							
L = 10 mH	Sustaining Voltage (Figure 1)  I, IB = 0, V <sub>Clamp</sub> = Rated V <sub>CEO</sub> )	BU323		VCEO(sus)	350 400			Vdc
	sustaining Voltage (Figure 1) = 100 Ohms, L = 500 μH)	BU323		VCER(sus)	400 475	N POWER D	DOLLIE	Vdc
	urrent RBE = 100 Ohms)	21078		not policer pids	nonal	BU323A are omotive lanifle	iU323, tol au	g mAdc
Collector Cutoff C (Rated V <sub>CBO</sub> , I				ІСВО		.88	oplication 1	mAdc
Emitter Cutoff Cu (V <sub>EB</sub> = 6 Vdc, I		100	Conte	I <sub>EBO</sub>	CM-S =	fied at -40°C	40	mAdc
ON CHARACTER	ISTICS <sup>1</sup>		I		DE S		.A.8	= 51
Current Gain  (IC = 3 Adc, VC)  (IC = 6 Adc, VC)  (IC = 10 Adc, VC)	E = 6 Vdc)	Ā	5	hFE	300 150 50	550 350 150	2000	6 550 r Testa Circu
Collector-Emitter S (IC = 3 Adc IB = (IC = 6 Adc, IB (IC = 10 Adc, IB (IC = 6 Adc, IB	= 60 mAdc) = 120 mAdc)	-	000	VCE(sat)		ssivation for Stability.		
Base-Emitter Satur (IC = 6 Adc, IB (IC = 10 Adc, IB (IC = 6 Adc, IB	= 120 mAdc)			VBE(sat)			2.2 3 2.4	Vdc
Base-Emitter On V (I <sub>C</sub> = 10 Adc, V				VBE(on)		1	2.5	Vdc
Diode Forward Vo (IF = 10 Adc)	Itage	sint)	AESSI	V <sub>f</sub>	logary?	2	3.5	Vdc
DYNAMIC CHAR	ACTERISTICS	2014	004	380	euzlO30	V J	opatioV i	actor-Envitue
Output Capacitano (V <sub>CB</sub> = 10 Vdc,	e I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	y de	8	C <sub>ob</sub>	089 <sup>V</sup>	165	350	pF
SWITCHING CHA	RACTERISTICS		21	91	3,	(1)	Peak	THE TOTAL TOTAL
Storage Time	(V <sub>CC</sub> = 12 Vdc, I <sub>C</sub> = 6 Adc,	sio A	ε	t <sub>s</sub>	81	7.5	15	- minuo s µs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 0.3 Adc) Fig. 2	atovy.	175	tf	79	5.2	15	μs
FUNCTIONAL TE	STS MARKET STATE OF THE STATE O	5200	1001	900	7 17	3°001 × 5T	5000	
Second Breakdown Base-Forward Bi	Collector Current with ased	36	00	IS/B	greT-LT	See Figure 10	sul sgeno)	E bins gnitere
Pulsed Energy Test	(See Figure 12)			IC2L	550	*		mJ

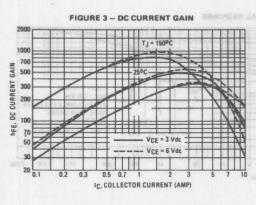
Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%.

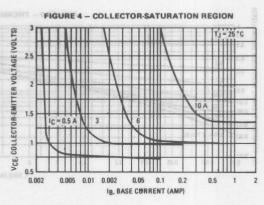


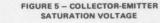
#### FIGURE 2 - SWITCHING TIMES TEST CIRCUIT

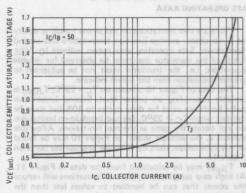




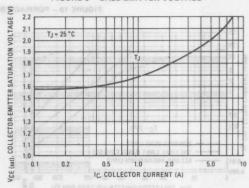


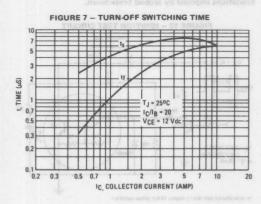


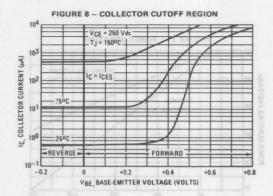














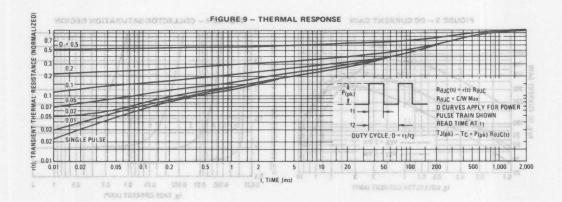
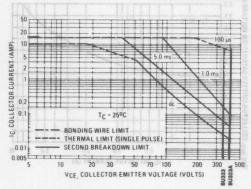
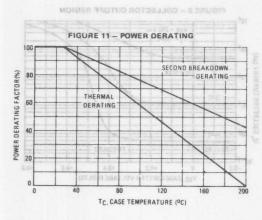


FIGURE 10 - FORWARD BIAS SAFE OPERATING AREA



PIGURE 5 - BASE-EMITTER VOLTAGE

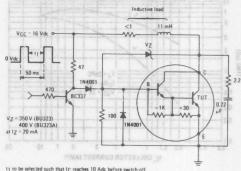


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 10 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current a, the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 12 - IGNITION TEST CIRCUIT



NOTE: Figure 12 specifies energy handling capabilities in an automotive ignition circuit

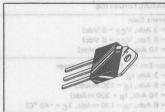


The BU323P, BU323APare monolithic darlington transistors designed for automotive ignition, switching regulator and motor control applications.

- Collector-Emitter Sustaining Voltage - V<sub>CER</sub> (sus) = 475 Vdc (Min. BU323AP)
- 125 Watts Capability at 50 Volts
- V<sub>CE</sub> Sat Specified at -40°C = 2 V : Max. at I<sub>C</sub> = 6 A
- 550 mJ Energy Capability Tested in Automotive Ignition Circuit
- Photoglass Passivation for Reliability and Stability



350 & 400 VOLTS



Collector

~ 20

Emitter

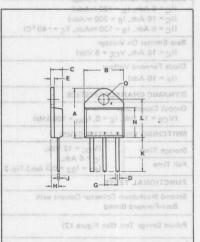
#### **MAXIMUM RATINGS**

20				
Rating	Symbol	BU323P	BU323AP	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	200	250	Vdc
Collector-Emitter Voltage	V <sub>CEV</sub>	300	350	Vdc
Emitter Base Voltage	V <sub>EB</sub>	Cob	7	Vdc
Collector Current – Continuous – Peak (1) – Overload	I <sub>C</sub> I <sub>CM</sub> I <sub>ol</sub>	50 100	40 80	Adc
Base Current – Continuous – Peak (1)	I <sub>B</sub>	10	16	Adc
Total Power Dissipation – $T_C = 25^{\circ}C$ – $T_C = 100^{\circ}C$ Derate above 25°C	P <sub>D</sub>		25 00 1	Watts Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 t	o +200	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>eJC</sub>	1	°C/W
Maximum Lead Temperature for Soldering Purposes: /// from Case for 5 Seconds	[β] <b>Τ</b> ι -√√√[ø]	275	°C

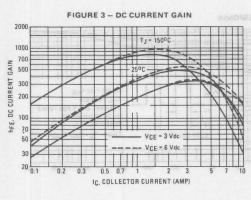
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle  $\leq$  10%.

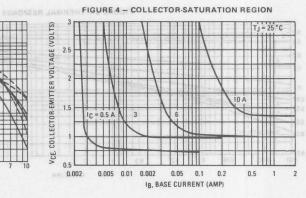


	MILLIA	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	20.32	21.08	0.800	0.830	
В	15.49	15.90	0.610	0.626	
C	4.19	5.08	0.165	0.200	
0	1.02	1.65	0.040	0.065	
E	1.35	1.65	0.053	0.065	
G	5.21	5.72	0.205	0.225	
н	2.41	3.20	0.095	0.126	
1	0.38	0.64	0.015	0.025	
K	12.70	15.49	0.500	0.610	
L	15.88	16.51	0.625	0.650	
N	12.19	12.70	0.480	0.500	
0	4.04	4.22	0.159	0.166	

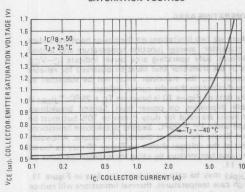
CASE 340-01 (TO-218AC)

23P 23AP	VCEO(sus) VCER(sus) ICER ICBO IEBO	350 400 400 475	.qvT .ccs.rare m eutomotive of application ler Sustainin = 475 Vd	Max.	Vdc Vdc mAdc mAdc	
23P 23AP 23P 23AP	VCER(sus)  ICER ICBO	400 400 475	automotive ol application ter Sustainin	ned for contract 1 or-Emi	Vdc	
23P 23AP 23P 23AP	VCER(sus)  ICER ICBO	400 400 475	automotive ol application ter Sustainin	ned for contract 1 or-Emi	mAdc	
23P 23AP	ICER	400 475	automotive ol application ter Sustainin	ned for contract 1 or-Emi	mAdc	
Colle	СВО	(M) o		im3-10		
elieo		(M) o			m Adc	
elle)	IEBO				- 90	
T				40	m Adc	
	-	PRINCIA.		itts Cal	SVV GZT 6	
	hFE	300 150 50	550 350 150	2000	V <sub>CE</sub> Sal Max. at 550 m <sub>4</sub>	
0 0 0 0	VCE(sat)	nu: idaileR	Ignition Civi ssivation for Ity		Photos potons in and	
um.s.	VBE(sat)			2.2 3 2.4	Vdc	
	VBE(on)			2.5	N Vdc	A
210	V <sub>f</sub> 200	Voccountries	2	3.5	Vdc	stic
360	038	Voev		Voltage	otor-Emitter	pite
	C <sub>ob</sub>	ъV	165	350	oV sa PF 18	in
UB	100	lou	1 20001	Hapt -	MINIES 1010	blik
	ts	50	7.5	15	μs	100
	भ	cred	3.2	117 200		
11	I <sub>S/B</sub>	9	See Figure 10	- noliteqi		7
-200	IC2L	550	netton	orage Je ange	mJ	ec p.T
	0 - S 0 - S	VBE(sat)  VBE(on)  Vf  Cob  ts tf  IS/B  IC2L 2	VBE(sat)  VBE(on)  Vf  Cob  Is/B  IC2L 2  FIGURE 2 — SW  Inter 700 Hz  Pulse Width - 1 ms	VBE(sat)  VBE(on)  Vf  2  Cob  165  t <sub>s</sub> 7.5  t <sub>f</sub> 5.2  IS/B  See Figure 10  IC <sup>2</sup> L  2  550  FIGURE 2 – SWITCHING TIMES  I <sub>tata</sub> 700 Hz  Police Wodth + 1 ms	1.7 2.7 2.0  VBE(sat)  2.2 3 2.4  VBE(on)  2.5  Vf  2 3.5  Cob  165 350  15 15 17 5.2 15  15/B  See Figure 10  1C2 L 2 550  FIGURE 2 – SWITCHING TIMES TEST CIF  1stst - 700 Hz Poist Width - 1 ms  VCC - 12V  2 2 550	VBE(sat)  VBE(sat)  VBE(on)  VGC 2.2 3 2.4  VGC 2.5  VGC

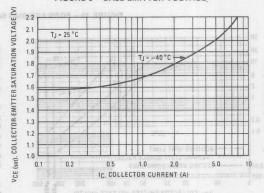


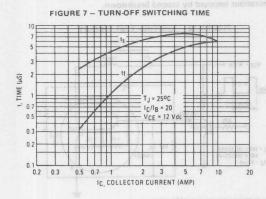


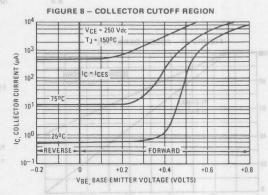














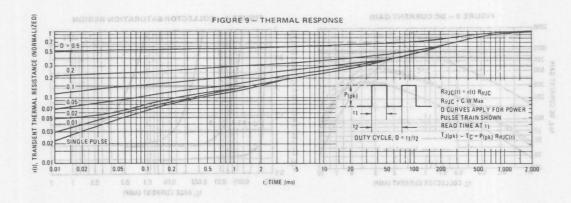
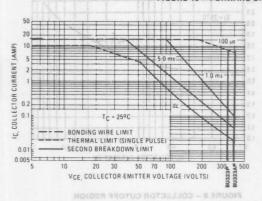
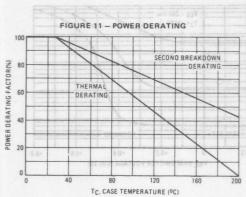


FIGURE 10 - FORWARD BIAS SAFE OPERATING AREA

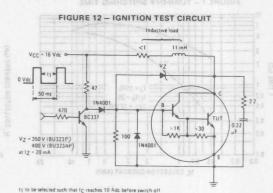




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 10 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



NOTE. Figure 12 specifies energy handling capabilities in an automotive ignition circuit

**BU326, BU326A** 



#### HIGH VOLTAGE NPN SILICON TRANSISTOR

... Designed for use in the switch-mode power supplies of colours cause television receivers.

- Collector-Emitter Voltage VCES = 800 V and 900 V
- Collector-Current IC = 6 A DC
- Low collector emitter saturation voltage VCE (sat) = 3 V max. at IC = 4 A
- Fall time at Ic = 2.5 A  $T_F = 1 \mu s \text{ max. at } T_C = 100 \,^{\circ}\text{C}$

NPN SILICON POWER TRANSISTORS

**6 AMPERES** 

375, 400 VOLTS 90 WATTS



### **MAXIMUM RATINGS**

Rating	Symbol	BU326	BU326A	Unit
Collector-Emitter Voltage	VCEO (sus)	375	400	Vdc
Collector-Emitter Voltage	VCES	800	900	Vdc
Emitter Base Voltage	VEB	1	0	Vdc
Collector Current - Continuous - Peak <sup>1</sup>	I <sub>C</sub> M	6 8		Adc
Base Current - Continuous - Peak <sup>1</sup>	I <sub>B</sub>	2 3		Adc
Reverse Base Current 20 ms max.  — Peak during turn off	I <sub>B</sub>	100		mA A
Total Power Dissipation Derate above 25 °C	PD	90 0.6		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +175		°C o

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	ROJC	1.65	°C/W

IOTES:

1. DIMENSIONS Q AND V ARE DATUMS.
2. T IS SEATING PLANE AND DATUM.
3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q. ♦ 0.13 (0.005) ⊕ T V ⊕ FOR LEADS: ♦ 0.13 (0.005) @ T V @ Q @ 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973. CASE 1-05 TO-3

<sup>&</sup>lt;sup>1</sup> Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

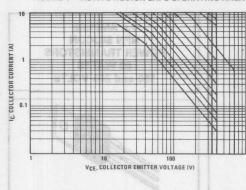
# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted)

3:	Characteristic	1	Sy	mbol	Min.	Тур.	Max.	Unit
OFF CHARACTER	SISTICS <sup>1</sup>					S MAN 3E	ATJOVE	HIGH
Collector-Emitter S (I <sub>C</sub> = 100 mA, I	ustaining Voltage B = 0, L= 25 mH)	BU326 BU326A		O (sus)	375 400	n the switch	seu noi be	Vdc
Collector-Cutoff Cu (V <sub>CE</sub> = 800 V, (V <sub>CE</sub> = 900 V,	V <sub>BE</sub> = 0)	BU326 BU326A	I,	CES V 008	tims V 008 =	839V agail	1.0	mAdc
	V <sub>BE</sub> = 0, T <sub>J</sub> = 125 °C) V <sub>BE</sub> = 0, T <sub>J</sub> = 125 °C)	BU326 BU326A	l (	CES		* 6 A DC r saturation r max, at fo		
Emitter Cutoff Cur (VEB = 10 V, I			16	ЕВО	341	At Tg = 100	X8/10 1 =	mAdc
ON CHARACTERI	STICS <sup>1</sup>							
DC Current Gain (IC = 0.6 A, VCE = 5 V)		L	h	FE		30		-
Collector-Emitter Saturation Voltage ( $I_C = 2.5 \text{ A}, I_B = 0.25 \text{ A}$ ) ( $I_C = 4.0 \text{ A}, I_B = 1.25 \text{ A}$ )			VCE	E (sat)			10	Vdc
Base-Emitter Satura (I <sub>C</sub> = 2.5 A, I <sub>B</sub> = (I <sub>C</sub> = 4.0 A, I <sub>B</sub> =	= 0.25 A)		VBE	E (sat)			1.4 mm 1.6	Vdc TASI MUMERA
DYNAMIC CHARA	CTERISTICS	L Hell 1	ARCEUR	85509	Tardening .		(map)	
	0 11 00	shV-	600	375	Jacat O∃o∀		Abetjo/	Pactor Emitter
Current-Gain – Ban (IC 200 mAdc, )	dwidth Product VCE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)		-	T 008	eso <sup>V</sup>	6		MHz 101 st
SWITCHING CHAP		Vdc		a a	Ol - Icea	base vortage to Current — Concinuous Bases		
Resistive Load (Tab	(e 1) (	Auto			81			ië Durnent – Cor
Turn On Time			t	on	MS		0.5	μs
Storage Time	(I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V)		.0	ts	81		3.5	μs
Fall Time	THAN COLOR PROPERTY OF THE PARTY OF THE PART	A		tf	9/8	0.3		μs
SUTA SI	// 25 A I-v - 05 A	Dollar.		0	9		D°	di evode stavel
Fall Time	$(I_C = 2.5 \text{ A}, I_{B1} = 0.5 \text{ A})$ $(I_{B2} = 1.0 \text{ A}, V_{CC} = 250 \text{ V}, T_{C})$	= 100 °C)	1176	tf an	TJ Tsig		1.0	μs

Pulse Test: Pulse Width = 300 \mus, Duty Cycle = 2%.



FIGURE 1 - ACTIVE REGION SAFE OPERATING AREA



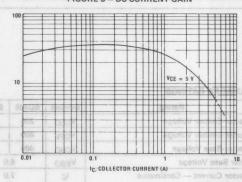
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on  $T_C = 25^{\circ}C$ ;  $T_J(p_K)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

> VCE(set) = 1.0 V (max) @ 5:0 A Packaged in Compact JEDEC TO-220AB

FIGURE 2 - "ON" VOLTAGES





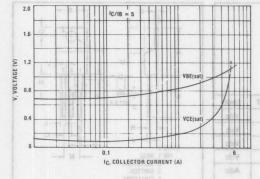


FIGURE 4 - RESISTIVE SWITCHING PERFORMANCE

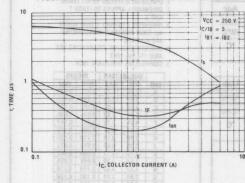
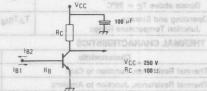


FIGURE 5 - SWITCHING TIMES TEST CIRCUIT



RC - RB: Non inductive resistances

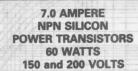


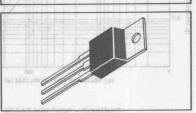
PIGURE 1 - ACTIVE HEGION SAFE OPERATING AREA

# **NPN POWER TRANSISTORS**

These devices are high voltage, high speed transistors for horizontal deflection output stages of TV's and CRT's.

- High Voltage:
- VCEV = 330 or 400 V
- Fast Switching Speed: t<sub>f</sub> = 750 ns (max)
- Low Saturation Voltage: VCE(sat) = 1.0 V (max) @ 5.0 A
- Packaged in Compact JEDEC TO-220AB





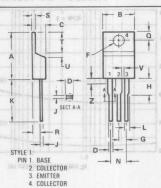
3

# **MAXIMUM RATINGS**

III Othinom Tottintoo				
Rating	Symbol	BU406	BU407	Unit
Collector-Emitter Voltage	VCEO	200	150	Vdc
Collector-Emitter Voltage	VCEV	400	330	Vdc
Collector-Base Voltage	VCBO	400	330	Vdc
Emitter Base Voltage	VEBO	6.0		Vdc
Collector Current — Continuous Peak Repetitive Peak (10 ms)	lc - e arum	1	7.0 10 15	
Base Current	IB	4	.0	Adc
Total Device Dissipation, T <sub>C</sub> = 25°C  Derate above T <sub>C</sub> = 25°C	PD		60 48	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>Stg</sub>	-65 to 150		°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	RøJC	2.08	°C/W
Thermal Resistance, Junction to Ambient	ROJA	70	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5.0 Seconds	TL	275	°C



- 4. DUTES:

  1. DIMENSION H APPLIES TO ALL LEADS.
  2. DIMENSION L APPLIES TO LEADS 1
  AND 3.
  3. DIMENSION Z DEFINES A ZONE WHERE
  ALL BODY AND LEAD IRREGULARITIES
  ARE ALLOWED.
  4. DIMENSIONING AND TOLERANCING PER
  ANSI VIA 5M. 1982

  - ANSI Y14.5M, 1982.
    5. CONTROLLING DIMENSION: INCH.

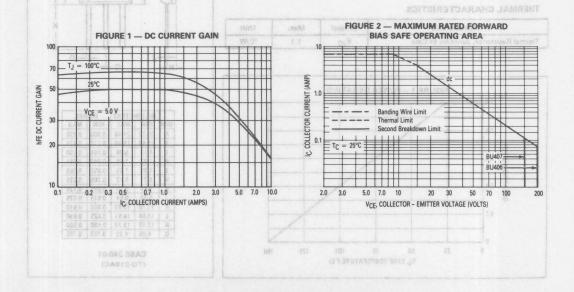
	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	.2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
10	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

TO-220AB

MOTOROLA

	,	
K.	á	ь

Characteristic			Sym	lod	Min	Тур	Max	Unit
OFF CHARACTERISTICS	50	18 UE 10	Aludna is	Wog sp	om penon	Ans aut un a	ned for us	pizeb
ing in income of the	BU406 BU407		VCEO	(sus)	200 150	Emitter Vo	Collector	Vdc
Collector Cutoff Current (VCE = Rated VCEV, VBE = 0) (VCE = Rated VCEO + 50 Vdc, VBE = 0) (VCE = Rated VCEO + 50 Vdc, VBE = 0, TC	= 150°C)	)	ICE	S	- V nations	tn 	5.0 0.1 1.0	mAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0)			aplee	30	g1,44 =	gl ⊕,ob/	1.0	mAdc
ON CHARACTERISTICS (1)					(Olia) di	(byd)	O.3 asec (	= 31
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc)			VCE	(sat)	_	<del>-</del>	1.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc	otes!	TARCALIR	VBE	(sat)	_		1.2	Vdc
DYNAMIC CHARACTERISTICS			New Assess					
Current-Gain — Bandwidth Product (IC = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 20 MHz	Veic (	000	000	eagV	10	0 = 38	V agastoV	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 1.0 MHz)	Vdc Adc		Co	b 63V		80	lege Constau	pF <sup>3-1873</sup>
SWITCHING CHARACTERISTICS		1	1				- Pagk	
Inductive Load Crossover Time  (V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 5.0 Adc, I <sub>R1</sub> = I <sub>R2</sub> = 0.5 Adc, L = 150 µH)	Arte Wasts W/90	8	S t	18 G9	-	C = 25°C	0.75	al Device Dis





# HIGH VOLTAGE NPN SILICON TRANSISTOR

... designed for use in the switched mode power supply of 90° and 110° colour television receivers.

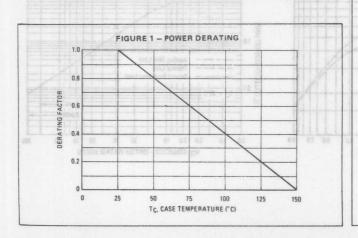
- High Collector-Emitter Voltage
   VCES = 800 V, 900 V
- Collector Current
   IC = 6 Adc
- Low Collector Emitter Saturation Voltage
   VCE(sat) = 3 Vdc, @IC = 4 A, IB = 1.25 Adc
- Fall Time @I<sub>C</sub> = 2.5 A, I<sub>B</sub> (end) = 1 A t<sub>f</sub> = 0,3 μsec (typ)

#### MAXIMUM RATINGS

Rating	Symbol	BU426	BU426A	Unit
Collector-Emitter Voltage	VCEO	375	400	Vdc
Collector-Emitter Voltage V <sub>BE</sub> = 0	VCES	800	900	Vdc
Emitter-Base Voltage	VEB		0	Vdc
Collector Current — Continuous — Peak	lc		6	Adc
Base Current	IB	2	2.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	113 0.90		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65	to 150	°Ç

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.1	°C/W

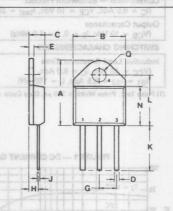


# 6 AMPERES

# TRIPLE DIFFUSED NPN SILICON POWER TRANSISTORS

800,900 VOLTS 113 WATTS





	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
8	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
1	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
0	4.04	4.22	0.159	0.166

CASE 340-01 (TO-218AC)

3

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS			PHADT	NS PAUD DO	HEREZ-	
Collector-Emitter Sustaining Voltage See Figure 8 (IC ≈ 100 mA, L = 25 mH)	BU426 BU426A	VCEO	375 400	0 = 32V		Vdç
Collector-Cutoff Current (VCES = Rated Value, TC = 25°C) (VCES = Rated Value, TC = 125°C)	d (	ICES			1.0	mAde
Emitter Cutoff Current VEB = 10 Vdc, IC = 0)	( passes - 2.0 S	IEBO		- I	10	mAde

#### ON CHARACTERISTICS

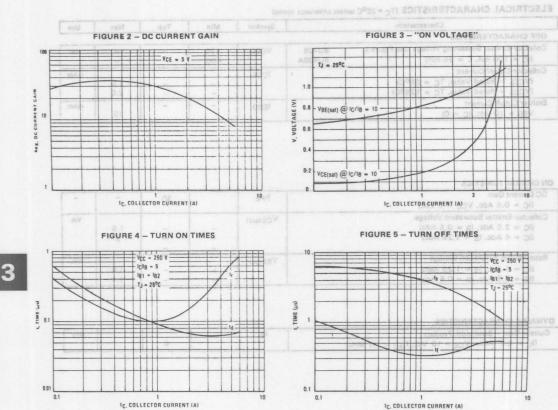
DC Current Gain (IC = 0.6 Adc, VCE = 5 Vdc)	PE	168	30	1382,31	-
Collector-Emitter Saturation Voltage (IC = 2.5 Adc, IB = 0.5 Adc) (IC = 4 Adc, IB = 1.25 Adc)	VCE(sat)	EBRRT	ио и <u>в</u> ит –	1.5	Vdc
Base-Emitter Saturation Voltage (IC = 4 Adc, IB = 1.25 Adc) (IC = 2.5 Adc, IB = 0.5 Adc)	VBE(sat)	V.	7 (2) 1 2	1.6	Voc

# DYNAMIC CHARACTERISTICS

Current Gain - Bandwidth Product		The lands		MH
(I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)			6	

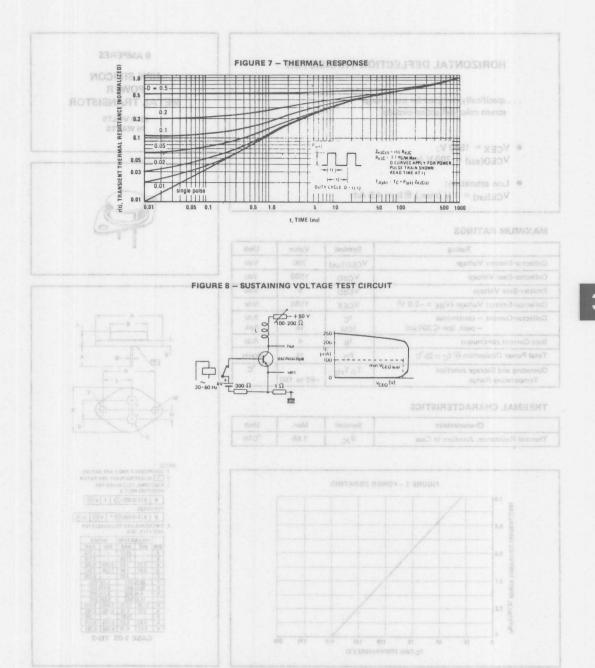
# SWITCHING CHARACTERISTICS (Resistive Load)

		MIN.	TYP.	MAX.	
	ton		0.2	0.6	μ
(I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V)	ts	1	2	3.5	
	tf	TV X	0.5		
(In = 25A Int = 05A)					μι
$(I_C = 2.5 \text{ A}, I_{B1} = 0.5 \text{ A})$ $(I_{B2} = 1.0 \text{ A}, V_{CC} = 250 \text{ V}, T_C = 95^{\circ}\text{C})$		K/		0.75	
	$(I_{B2} = 1.0 \text{ A}, V_{CC} = 250 \text{ V})$ $(I_{C} = 2.5 \text{ A}, I_{B1} = 0.5 \text{ A})$ $(I_{B2} = 1.0 \text{ A}, V_{CC} = 250 \text{ V}, T_{C} = 95^{\circ}\text{C})$	(I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V) (I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V, T <sub>C</sub> = 95°C)	(I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V)  (I <sub>C</sub> = 2.5 A, I <sub>B1</sub> = 0.5 A) (I <sub>B2</sub> = 1.0 A, V <sub>CC</sub> = 250 V, T <sub>C</sub> = 95°C)		



There are two limitations on the power handling ability of a transistor: average junction temperature and second break down. Safe operating area curves indicate [C-VCc limits of the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 6 is based on TJ(pk) 150°C, Tc isvariable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10°Po provided TJ(pk) 150°C. TJ(pk) may be calculated from the data in figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN 415A)





#### HORIZONTAL DEFLECTION TRANSISTOR

... specifically designed for use in large screen color deflection circuits

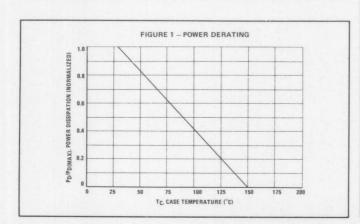
- VCEX = 1500 V; VCEO(sus) = 700 V (min.)
- Low saturation: VCE(sat) = 1 V (max.) @ Ic = 4.5 Adc

# **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	700	Vdc
Collector-Base Voltage	VCBO	1500	Vdc
Emitter-Base Voltage	VEBO	5	Vdc
Collector-Emitter Voltage (V <sub>BE</sub> = -2.0 V)	VCEX	1500	Vdc
Collector-Current — continuous — peak (pw ≤ 300 μs)	IC ICM	6 16	Adc Apk
Base-Current continuous	I <sub>B</sub>	4	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	75	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 150	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.66	°C/W

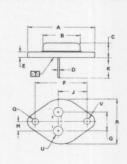


#### 6 AMPERES

NPN SILICON POWER **METAL TRANSISTOR** 

> **1500 VOLTS** 75 WATTS





# NOTES: 1. DIMENSIONS 0 AND V ARE DATUMS. 2. T IS SEATING PLANE AND DATUM. 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE 0

- ♦ | 0.13 (0.005) ⊗ | T | V ⊗
- ♦ 13 (0.005) ⊕ T V ⊕ Q ⊕
- 4 DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

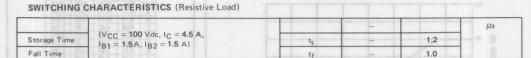


CASE 1-05 TO-3



23H39MA Characteristic		SHULL	Symb	ool	Min.	Max.	Unit
OFF CHARACTERISTICS (1)		rugtuo tius	orio neite	ngi es	sended for use	nistor mainly	Power Tra
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 0) L = 10 mH			VCEO	(sus)	700 Pales	d minimum su	DDV Specifik VCERE
Collector Cutoff Current at Reverse Bias: (V <sub>CE</sub> = 1000 V, I <sub>E</sub> = 0) (V <sub>CE</sub> = 1500 V, I <sub>E</sub> = 0)			СВ	0	8U522A) 8U522B)	0.02 1.0	mAdc
Collector-Emitter Cutoff Current (V <sub>CE</sub> = 1500 V, V <sub>BE</sub> = -2 V)			ICE	×	8) at IC = 5 A 2A, 8U5228)	1.0 004	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 100 mA)		(822808)	VEE	30	5	X(set) = 2.0	V
Emitter Cutoff Current (VEB = 4 V)	tiast	auszaua	IEB	0	lodm)	10 2003	mAdc
	Vdc	425	400	350	Nosessoul	Voltage Sust.	Hector-Enviran
	gbV	450	425	376	VCER		

3-1-				llector Current - Continuous
ON CHARACTERISTICS (1)				
DC Current Gain	100	hEE	1 8	7/19YUQ 8
$(I_C = 4.5  \text{Adc},  V_{CE} = 5  \text{V})$		92	3.0	ual Device Distination (ii) To = 25°C
Collector-Emitter Saturation Voltage	1 2 2 1	VCE(sat)		Vdc
(I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 2 A)	100	CL(sat/	graT -t.T	no1:0 ul age of 0 bas gallers
1 3 M 1		08 to 80-		Temperature Flange
Base-Emitter On Voltage $(I_C = 4.5 \text{Adc}, V_{CE} = 2 \text{ A})$		VBE(on)	83	Vdc
0 1 1	Unit	Symbol   Nax.		Characteristic



(1) Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\leqslant$  2%.

8.4000 OY

FIGURE 1 - FOWER DERATING



#### HIGH VOLTAGE SILICON POWER DARLINGTONS

Power Transistor mainly intended for use as ignition circuit output transistor.

Specified minimum sustaining voltage:
 VCER(sus) = 350 V (BU522)
 at I<sub>C</sub> = 1 A 400 V (BU522A)

425 V (BU522B)

 High S.O.A. capability:
 VCE = 350 V (BU522) at IC = 5 A 400 V (BU522A, BU522B)

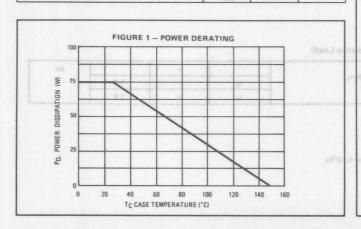
Low V<sub>CE(sat)</sub> = 2.0 V max. at I<sub>C</sub> = 4 A (BU522A, BU522B)

### MAXIMUM RATINGS

Rating Sy	mbol	BU522	BU522A	BU522B	Unit
Collector-Emitter Voltage Sust.	VCER (sus)	350	400	425	Vdc
Collector-Emitter Voltage	VCER	375	425	450	Vdc
Collector-Base Voltage	VCBO	400	450	475	Vdc
Emitter-Base Voltage	VEBO		5.0		Vdc
Collector Current - Continuous	¹c	7.0			Adc
Base Current	I <sub>B</sub>	2.0			Adc
Total Device Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	OP <sub>D</sub>	75 0.60			Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	115	-65 to 15	60	00

# THE MAL CHARACTERISTICS

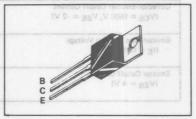
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	$\theta_{\rm JC}$	1.67	°C/W

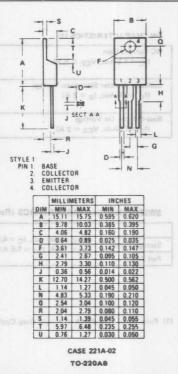


# SOLIZING FOAHANO JAONH 10933 SINGNOSEMAC 7 AMPERES

DARLINGTON
TRIPLE DIFFUSED
POWER TRANSISTORS
NPN SILICON

375, 425, 450 VOLTS 75 WATTS





3

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

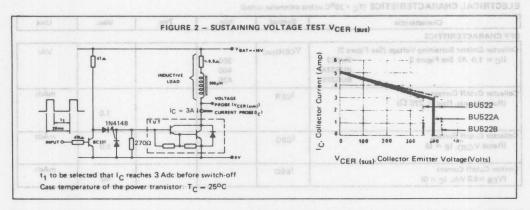
Characteristic	Symbol	Min.	Тур.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (See Figure 2) (I <sub>C</sub> = 1.0 A) See Figure 2  BU522  BU522A  BU522B	VCER(sus)	350 400 425	\$1000 DUCAN	Atti	Vdc
Collector Cutoff Current (Rated V <sub>CER</sub> , R <sub>BE</sub> = 270 Ω)	ICER	SOUTH THE SOUTH OF	A8 - 51	1.0	mAdc
Collector Cutoff Current (Rated V <sub>CBO</sub> , I <sub>E</sub> = 0)	СВО		alo jov	1.0	mAdc
Emitter Cutoff Current (VEB = 5.0 Vdc, IC = 0)	IEBO	Ho-riotine I	thes 3 Ade belon	40 140	mAdc

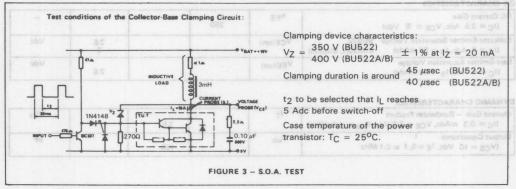
#### ON CHARACTERISTICS

DC Current Gain $(I_C = 2.5 \text{ Adc}, V_{CE} = 5 \text{ Vdc})$	hFE	250	(California Base Ca	ailt to moiribre	in the T -
Collector-Emitter Saturation Voltage BU522 (IC = 4 Adc, IB = 80 mAdc) BU522A, BU522A	VCE(sat)	10 V S		2.5	Vdc
Base-Emitter Saturation Voltage (IC = 4 Adc, IB = 80 mAdc)	V <sub>BE</sub> (sat)	0/1	service	2.5	Vdc

# DYNAMIC CHARACTERISTICS I I tam betoeles ed at gr

Current Gain - Bandwidth Product	fT	1 1		WELLAR T	MHz
(I <sub>C</sub> = 0.3 mAdc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	Case	-14	7.5	1-1/10	
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz	Cob	Van T	150	PIT	pF





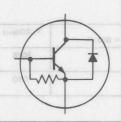


# NPN SILICON HORIZONTAL DEFLECTION TRANSISTOR WITH INTEGRATED DAMPER DIODE

... specifically designed for use in large screen color deflection circuits



VCEO(sus) = 700 V

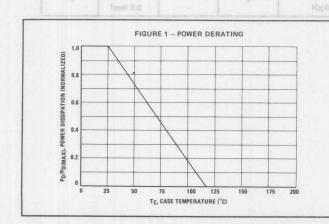


#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	700	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 0)	VCES	1500	Vdc
Emitter-Base Voltage	VEB	5	Vdc
Collector-Current — Continuous — Peak	IC ICM	5 10	Adc
Base Current — Peak	IB	2.5	Adc
Total Device Dissipation T <sub>C</sub> = 25 °C Derate above 25 °C	PD	60 0.666	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 115	°C

# THERMAL CHARACTERISTICS

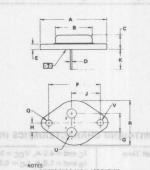
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	$\theta_{\sf JC}$	1.5	°C/W



# ELECTRICAL CHARACTERISTICS (T 5 AMPERES NPN SILICON POWER TRANSISTOR

(1) specific v1500 VOLTS 1003 vorselled 60 WATTS - 001 = 517





- NOTES

  1. DIMENSIONS O AND V ARE DATUMS.
  2. T) IS SEATING PLANE AND DATUM.
  3. POSITIONAL TOLERANCE FOR MOUNTING HOLE O.
  - - ♦ \$.13 (0.005) ⋈ T V ⋈ FOR LEADS:
  - # 0.13 (0.00\$) ⊕ T V ⊕ 0 ⊕

    4. DIMENSIONS AND TOLERANCES PER
    ANSI Y14.5, 1973.

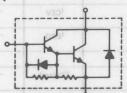
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	-	39.37	-	1.550
B	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	-	3.43	-	0.135
F	30,15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
Н	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	11.18	12.19	0.440	0,480
0	3.81	4.19	0.150	0.165
R	-	26.67	-	1,050
U	4.83	5.33	0.190	0.210
٧	3.81	4.19	0.150	0.165

3

#### NPN DARLINGTON POWER TRANSISTORS

These Darlington transistors are high voltage, high speed devices for horizontal deflection circuits in TV's and CRT's.

- High Voltage: VCEV = 330 or 400 V
- Fast Switching Speed:  $t_C = 1.0 \,\mu\text{s} \,(\text{max})$
- Low Saturation Voltage: VCE(sat) = 1.5 V (max)
- Packaged in JEDEC TO-220AB
- Damper Diode V<sub>F</sub> is specified. VF = 2.0 V (max)



POTENTY 8.0 AMPERE

DARLINGTON NPN POWER **TRANSISTORS** 

60 WATTS 150 and 200 VOLTS

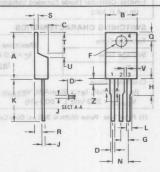


## **MAXIMUM RATINGS**

Rating	Symbol	BU806	BU807	Unit
Collector-Emitter Voltage	VCEO	200	150	Vdc
Collector-Emitter Voltage	VCEV	400	330	Vdc
Collector-Base Voltage	Vсво	400	330	Vdc
Emitter-Base Voltage	VEBO	6	.0	Vdc
Collector Current — Continuous — Peak	IC	1	.0	Adc
Emitter-Collector Diode Current	I IF week	108 Jan 1	0	Adc
Base Current	IB	2	.0	Adc
Total Device Dissipation, T <sub>C</sub> = 25°C  Derate above T <sub>C</sub> = 25°C	PD	1 200	60 48	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,	-65 t	o 150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	2.08	°C/W
Thermal Resistance, Junction to Ambient	R <sub>0</sub> JA	70	°C/W
Lead Temperature for Soldering Purposes, 1/8" from Case for 5.0 Seconds	O.E. TL	275	°C



- NOTES:

  1. DIMENSION H APPUES TO ALL LEADS.

  2. DIMENSION L APPUES TO LEADS 1
  AND 3.

  3. DIMENSION 2 DEFINES A 2002 WHERE
  ALL BOOVED, AND LEAD WIREGULARITIES
  ARE ALLOWED.

  4. DIMENSIONING AND TOLERANCING PER
  ANSI Y14 SM. 1982.

  5. CONTROLING DIMENSION: INCH.

	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

CASE 221A-02 TO-220AB



	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERIST	ics	610	projesta	or name	A A TOTAL A		BITT
		BU806 BU807	V <sub>CEO(sus)</sub>	200 150		a Dar <del>li</del> ngtor	The second second
Collector Cutoff Curren (VCE = Rated VCBO, V			ICES	400 V		100	-
Collector Cutoff Curren (VCE = Rated VCEV, V		p	ICEV	-17 -		5 1.0 us (ma	μAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0	0)		IEBO	1 0	1	Sat 0.8 ion	
ON CHARACTERISTI	CS (1)	14	of Los	6/	EC TO-220	13t ni bagai	6 Paci
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 50 mAdc)			VCE(sat)	1 - 1		te 2.0 V (m)	
Base-Emitter Saturatio (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 50		0	V <sub>BE(sat)</sub>	_	-	2.4	Vdc
Emitter-Collector Diode (IF = 4.0 Adc)	Forward Voltage		VF	-	-	2.0	Vdc
SWITCHING CHARA	CTERISTICS						-
Turn-On Time	(Resistive Load, VCC	= 100 Vdc	ton		0.35		μS
Storage Time	IC = 5.0 Adc, IB1 =	50 mAdc,	ts	-	0.55	-	μS
Fall Time	I <sub>B2</sub> = 500 m	Adc)	tf	_	0.20	-	μS
Crossover Time (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 5 V <sub>clamp</sub> = 200 Vdc, L	0 mAdc, VBE(off) = 4.0 Vdc,		t <sub>c</sub>	-	0.40	1.0	μѕ
1) Pulse Test: Pulse Widt	h ≤ 300 μs, Duty Cycle ≤ 1%.	net I vocus	I sosua I	ludmy2		Restop	
1-11-11	1-1-	sbV 081				epsileV rate	



#### FIGURE 2 - SAFE OPERATING AREA (FBSOA) 10 non-repetitive 1 1.0 ms 10 μs CURRENT (AMPS) 1.0 Banding Wire Limit COLLECTOR ( Thermal Limit Second Breakdown Limit BU807 ن 50 ms BU806 0 3.0 0.2 0.3 0.5 0.7 1.0 2.0 3.0 5.0 7.0 10 IC. COLLECTOR CURRENT (AMPS) V<sub>CE</sub>, COLLECTOR-EMITTER VOLTAGE (VOLTS)

7.14 | 2.03 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 |

MADSS-OT



#### SWITCHMODE II SERIES **NPN SILICON POWER TRANSISTORS**

The BUS36 and BUS37 transistors are designed for low voltage, high speed, power switching in inductive and resistive circuits where turn-off times are critical. They are particularly suited for batteryoperated Switchmode applications and driver applications such as :

0

Switching Regulators

- Inverters
- Solenoid and Relay Drivers
- Motor Controls

Fast Turn-Off Times

60 ns Inductive Fall Time - 25°C (Typ) 110 ns Inductive Crossover Time - 25°C (Typ)

Operating Temperature Range - 65 to + 175°C

100°C Performance Specified for :

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents (125°C)



#### **NPN SILICON POWER TRANSISTORS**

120 & 150 VOLTS **107 WATTS** 

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries - are given to facilitate "worst case" design.

-0



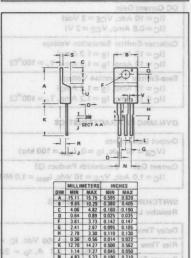
#### **MAXIMUM RATINGS**

Rating	Symbol	BUS36	BUS37	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	120	150	Vdc
Collector-Emitter Voltage	VCEV	250	300	Vdc
Emitter Base Voltage	-V <sub>EB</sub>		8	Vdc
Coflector Current — Continuous — Peak(1) — Overload	I <sub>C</sub>		12 25 40	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	doQ	7 15	Adc
Total Power Dissipation - T <sub>C</sub> = 25°C - T <sub>C</sub> = 100°C Derate above 25°C	P <sub>D</sub>		07 53 .71	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 t	o + 175	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.4	°C/W
Maximum Lead Temperature for Soldering Purposes:	Т	275	°C
1/8" from Case for 5 Seconds		15	(7c=2

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



A CASE 221A-02 TO-220

.(1) Pulpa Tast: PW = 300 ns, Duty Cycle S 2%



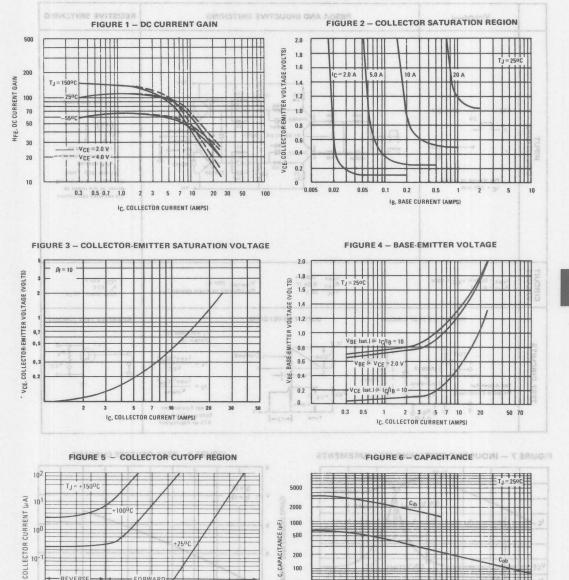
Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)		20	OTRIBIA	AFR TR	LICON POL	IR MUM	
Collector-Emitter Sustaining Voltage (Table 1)			VCEO(sus)	1 1 1 1 1 1 1 1			Vdc
$(I_C = 50 \text{ mA}, I_B = 0)$ L = 25 mH	908	BUS36	of bampiash	120	BUSST main	ns BEZUS	oriT
120 & 150 VOLTS	proc	BUS37	evitaism bru	150	avitoning in	swoo bas	pe ripiri
Collector Cutoff Current	-V18	ted tot l	ICEV	men ans	critical, The	times an	mAdo
(V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vdc)		as ribuz a	rapplication	iánh l <del>u</del> ns a	dis application		- operate
(V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vdc,	TC = 125 °C)	9		-	-	1.0	
Collector Cutoff Current			CEO		61020	Desi Bund	mAdc
"Viorst Cess" Conditions	BUS36 : VCE BUS37 : VCE					0.05	eval a
The Designors A Date Sheet parmits the	D0007 . VCE	- 75 V			day Drivers	A bos bior	e Sote
Emitter Cutoff Current (VEB = 6 Vdc, IC = 0)			IEBO			0.1	mAdo
TVEB = 0 Voc, IC = 0)		Lad.	211			mi T in C in	7 741
Emitter-base breakdown Voltage (IF = 50 mA - IC = 0)			BAEBO	8.0	e Fall Time —	ns Inductiv	Vdc
115 00 1111 10 01	-	100	(ayT)	P 20 - 80	A Chasenvay T	litechnise	ort
SECOND BREAKDOWN				35 to + 17	tura Range – t		
Second Breakdown Collector Current with Base	Forward Biase	ed	Is/b	artine Lo	See Fig	jure 12	10070
Clamped Inductive SOA with Base Reverse Biase	ed		RBSOA	ive Loads	See Fig	jure 13	SW
					sage.	mation voi	186
ON CHARACTERISTICS (1)						kaga Curye	En.J
DC Current Gain			hFE				-
(IC = 10 Adc, VCE = 2 Vdc)				30	-	-	
(I <sub>C</sub> = 0.5 Amp, V <sub>CE</sub> = 2 V)				50	-	RATTMOS	MUMICXA
Collector-Emitter Saturation Voltage		48308	VCE(sat)	Symbol		cortrast.	Vdc
$(I_C = 12 \text{ Amp}, I_B = 1.2 \text{ Amp})$ $(I_C = 12 \text{ Amp}, I_B = 1.2 \text{ Amp}, T_c = 100^{\circ}\text{C})$				-		0.8	
Base-Emitter Saturation Voltage	Vdc	180	Vast	VCECIAL	-	ter Voltage	Vdc
(I <sub>C</sub> = 12 Amp, I <sub>B</sub> = 1.2 Amp)	Vdo		VBE(sat)	VECEV	-	1.8	mā-rojoe
$(I_C = 12 \text{ Amp, } I_B = 1.2 \text{ Amp, } T_c = 100^{\circ}\text{C})$	Vde		8	ggV-	-	1.8	itter Base
DYNAMIC CHARACTERISTICS	abA			)(	snon	ent - Contin - Peak(1	lector Corn
			26	101	138	- Overlo	
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 khz)	Ado		Cob	Mai-	81	300	pF
-0-0							
Current Gain = Bandwidth Product (2) (I <sub>C</sub> = 1.0 Ade, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MH	Watts		fT	30	Tc = 26°C	noingisell	MHz
TIC = 1.0 Add, VCE = 10 Vdc, Itest = 1.0 MI	Join .	1	ta I	30		te 25°C	toda elsist
SWITCHING CHARACTERISTICS Resistive Load (Table 1)	200	179	or 88 -	Ti. Tate		Storage Ju e Range	
Delay Time			t <sub>d</sub>	_	0.07	0.15	μς
Rise Time (VCC = 100 Vdc, IC =			tr		0.15	0.3	
Storage Time IB1 = 1.2 A, tp = 30 Duty Cycle ≤ 2%, VBE		2	ts	myd-	0.5	1.0	1
Fall Time	(off) = 5 V)		tf	-	0.12	0.25	
Inductive Load, Clamped (Table 1)	ANTO			60	1	1,800,000	Jana Rema D of notion
	1 30		10	P	1 05	promot u	p. marris
Storage Time (IC(pk) = 12 A,	(TC	= 25°C)	t <sub>sv</sub>	-	0.5	180800109	prinai #\$
181 = 1.2 A,	-		tfi	-	0.06	2988 <u>101</u> 5	mott "8/1
Storage Time VRF(off) = 5 V		100	tsv	ity Gydle \$	3 .em 0.6 dib	V =1.0	Pulse Ty
Storage Time VBE(off) = 5 V, VCE(c1) = 100 V)	(TC=	100°C)	-24				

2 10-2

10-3

50 100

#### DC CHARACTERISTICS TO THE TANK



100

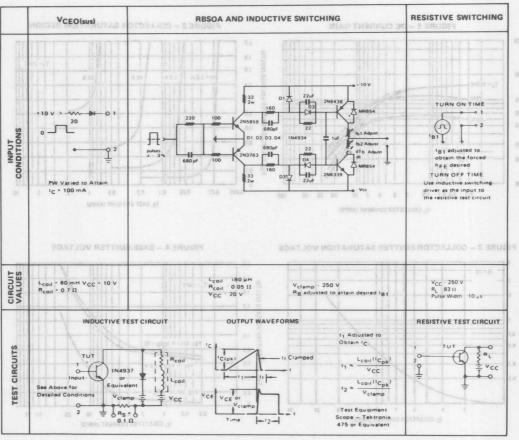
0.2

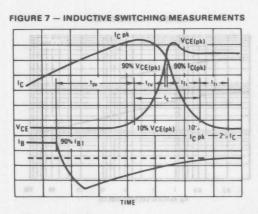
VR, REVERSE VOLTAGE (VOLTS)

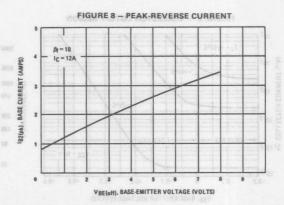
VCE = 50 V

VBE, BASE-EMITTER VOLTAGE (VOLTS)

TABLE 1 – TEST CONDITIONS FOR DYNAMIC PERFORMANCE







#### MOITAMHORM ARRA OMITAMINO HIM SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub> try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC Touche between

sid tti = Current Tail, 10-2% IC some and stands ton co

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms.

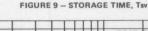
The Safe Operating Area Signes after

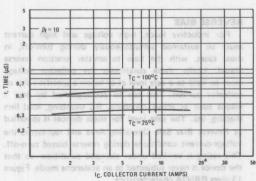
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

In general, try + tfi = tc. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are quaranteed at 100°C.

#### INDUCTIVE SWITCHING





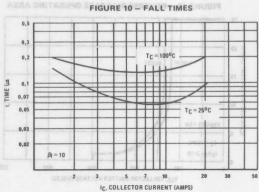


FIGURE 11a - TURN-OFF TIMES vs FORCED GAIN

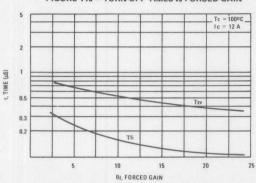
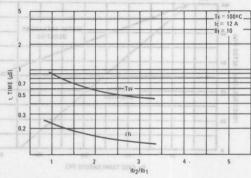


FIGURE 11b - TURN-OFF TIMES vs lb2/lb1



The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

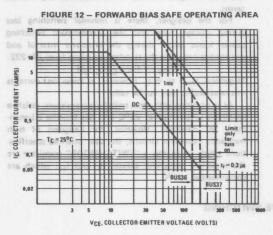


FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA

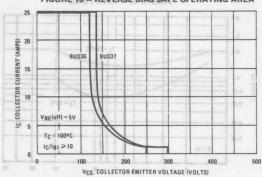
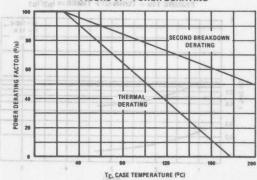


FIGURE 14 - POWER DERATING



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS .. yiegs bus bonileb need event semily

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C = 25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

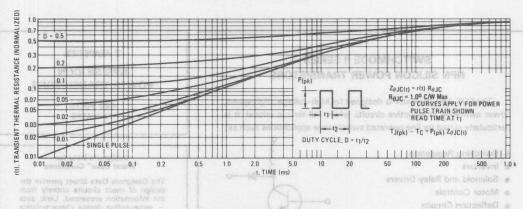
T<sub>J</sub>(p<sub>k</sub>) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by seve I means such as active clamping, RC snubbing, load ling shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.



FIGURE 15 - THERMAL RESPONSE



**OVERLOAD CHARACTERISTICS** 

FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA



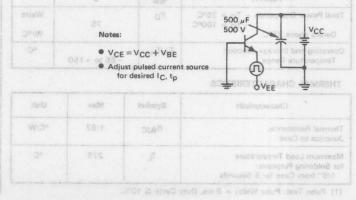
# AOZJO Time-25°C (Typ)

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 17) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

#### FIGURE 17 - OVERLOAD SOA TEST CIRCUIT





# SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The BUS 45P transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. It is particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

100 ns Inductive Fall Time – 25°C (Typ)

150 ns Inductive Crossover Time - 25°C (Typ)

400 ns Inductive Storage Time—25°C (Typ)

Operating Temperature Range -65 to +150°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages Leakage Currents

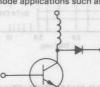


FIGURE 15 - THERMAL RESPONSE

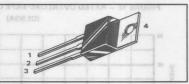
#### 3 AMPERES

## NPN SILICON POWER TRANSISTORS

450 VOLTS 75 WATTS

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data – representing device characteristics boundaries – are given to facilitate "worst case" design.



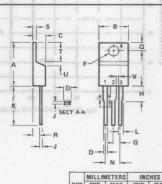
#### MAXIMUM RATINGS

Rating Rating	Symbol	BUS 45P	Unit
Collector-Emitter Voltage	VCEO(sus)	450	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage	VEB	Tantgirl 6	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub>	3 5	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	1.5	Adc
Total Power Dissipation $-$ T <sub>C</sub> = 25°C $-$ T <sub>C</sub> = 100°C Derate above 25°C	PD	75	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.67	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

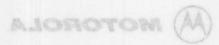
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



			MILECIA	METERS	HITC	HEO
		DIM	MIN	MAX	MIN	MAX
		A	15.11	15.75	0.595	0.620
		В	9.65	10.29	0.380	0.405
		C	4.06	4.82	0.160	0.190
		D	0.64	0.89	0.025	0.035
STYLE 1:		F	3.61	3.73	0.142	0.147
PIN 1.	BASE	G	2.41	2.67	0.095	0.105
2.	COLLECTOR	Н	2.79	3.30	0.110	0.130
3.	EMITTER	J	0.36	0.56	0.014	0.022
4.	COLLECTOR	K	12.70	14.27	0.500	0.562
		L	1.14	1.27	0.045	0.050
		N	4.83	5.33	0.190	0.210
		Q	2.54	3.04	0.100	0.120
		R	2.04	2.79	0.080	0.110
		S	1.14	1.39	0.045	0.055
		T	5.97	6.48	0.235	0.255
		U	0.76	1.27	0.030	0.050
		٧	1.14		0.045	*
	CAS	SE 2	21A-0	02		15

TO 220

3



CASE 221A-02

5,55,536,6	Characteristic			Symbo	l Mi	n	Тур	Max	Unit
OFF CHARACTERIS	STICS (1)			63IM	as II au	Uten	NO INVE		
Collector-Emitter Su	ustaining Voltage (Table 1) B = 0)		58	VCEO(su	is) 45	0	HOOLIN	-	Vdc
	rrent VBE(off) = 1.5 Vdc) VBE(off) = 1.5 Vdc, TC	= 100	is oritical, it is successful.	ICEV	stantus alie		translatori n indective tor tim-cos	0.5 2.5	mAdc 19woq
Collector Cutoff Cu (VCE = 850 V, F	rrent RBE = 50 Ω, TC = 100° (	C)	3	ICER	-		-	3.0	mAdc
Emitter Cutoff Curre (VEB = 6.0 Vdc,			į	IEBO	-		-	1.0	mAdc
ON CHARACTERIS			Š	D-191	o (T) 0°8s -				e Defle Fast Tur
DC Current Gain	E = 5.0 Vdc)			hFE	6	ge Ti	ctive Stora	ubni an O	A -
Collector-Emitter Saturation Voltage (IC = 2 Adc, IB = 0.5 Adc) (IC = 3 Adc, IB = 0.75 Adc) (IC = 2 Adc, IB = 0.5 Adc, TC = 100°C)			VCE(sa	t)		tions itleng a Specifie	1.0	Vdc	
(IC = 3 Adc, IB		C)					mes with I	3.0 2.0	8
(IC = 3 Adc, IB : (IC = 2 Adc, IB : (IC = 2 Adc, IB :	= 0.5 Adc, TC = 100° ( ation Voltage				dve Lesda				Vdc
(IC = 3 Adc, IB : (IC = 2 Adc, IB : (IC = 2 Adc, IB :	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc)		489	VBE(sat	dve Lesda		ntes with I	1.5 1.5	
(IC = 3 Adc, IB : (IC = 2 Adc, IB : (IC = 2 Adc, IB :	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)	)		VBE(sat	t)		ntes with I	2.0 1.5 1.5	MUMBKA
(IC = 3 Adc, IB (IC = 2 Adc, IB Base-Emitter Sature (IC = 2 Adc, IB (IC = 2 Adc, IB	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)	3991		VBE(sat	todaya		euganio euganio ema	1.5 1.5 20444AA	Vdc  MUMUMA  Sm3-restoelle
(IC = 3 Adc, IB (IC = 2 Adc, IB )  Base-Emitter Satura (IC = 2 Adc, IB ) (IC = 2 Adc, IB ) (IC = 2 Adc, IB )  SWITCHING CHAR Resistive Load (Tal Delay Time	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ACTERISTICS ble 1)	1mit 1dc 1dc		VBE(sat	todaya		0.03	2.0 1.5 1.5	MUNUX AF
(IC = 3 Adc, IB (IC = 2 Adc, IC = 2 Adc, IB (IC = 2 Adc, IB (I	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  AACTERISTICS ble 1)  (VCC = 250 Adc, IC =	) = 2 A,	7 08 7 3	VBE(sat	todaya		0.03	2.0 1.5 1.5 0.05 0.40	MUMIX AI
(IC = 3 Adc, IB (IC = 2 Adc, I	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ACTERISTICS ble 1)  (VCC = 250 Adc, IC = 181 = 0.5 Adc, tp = 3	= 2 A, 30 μs,	7 08 7 3 4 3	VBE(sat	todaya		0.03 0.10 0.40	2.0 1.5 1.5 0.05 0.40 1.50	MUMBX AF
(IC = 3 Adc, IB (IC = 2 Adc, IC = 2 Adc, IB (IC = 2 Adc, IB (I	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  AACTERISTICS ble 1)  (VCC = 250 Adc, IC =	= 2 A, 30 μs,	7 08 7 3 4 3	VBE(sat	todaya		0.03	2.0 1.5 1.5 0.05 0.40	MUMIX AI
(IC = 3 Adc, IB (IC = 2 Adc, I	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ***ACTERISTICS** ble 1)  (VCC = 250 Adc, IC = 181 = 0.5 Adc, tp = 3  Duty Cycle ≤ 2%, VBE	= 2 A, 30 μs,	7 08 7 3 4 3	VBE(sat	todaya		0.03 0.10 0.40	2.0 1.5 1.5 0.05 0.40 1.50	MUMIX AI
(IC = 3 Adc, IB (IC = 2 Adc, IB (IC = 2 Adc, IB Base-Emitter Sature (IC = 2 Adc, IB (IC = 2 Ad	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ***ACTERISTICS** ble 1)  (VCC = 250 Adc, IC = 181 = 0.5 Adc, tp = 3  Duty Cycle ≤ 2%, VBE	= 2 A, 30 μs,	7 08 7 3 4 3	VBE(sat	todaya todaya todaya vasiv		0.03 0.10 0.40	2.0 1.5 1.5 0.05 0.40 1.50 0.50	MUNBX Af
(IC = 3 Adc, IB (IC = 2 Adc, IB (IC = 2 Adc, IB Base-Emitter Sature (IC = 2 Adc, IB (IC = 2 Ad	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ***ACTERISTICS** ble 1)  (VCC = 250 Adc, IC = 181 = 0.5 Adc, tp = 3  Duty Cycle ≤ 2%, VBE	= 2 A, 30 μs, E(off) =	5.0 Vdc)	VBE(sat	todaya todaya todaya vasiv	3	0.03 0.10 0.40 0.175	2.0 1.5 1.5 1.5 0.05 0.40 1.50 0.50	MUNBX Af
(IC = 3 Adc, IB (IC = 2 Adc, I	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ACTERISTICS ble 1)  (VCC = 250 Adc, IC = IB1 = 0.5 Adc, Ip = 3 Duty Cycle ≤ 2%, VBE  amped (Table 1)  (IC(pk) = 2 A, IB1 = 0.5 Adc,	= 2 A, 30 μs, E(off) =	5.0 Vdc)	VBE(sat	todays	3- 39	0.03 0.10 0.40 0.175	2.0 1.5 1.5 0.05 0.40 1.50 0.50	MUMUX AF
(IC = 3 Adc, IB (IC = 2 Adc, IB (IC = 2 Adc, IB IC	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ACTERISTICS ble 1)  (VCC = 250 Adc, IC = 181 = 0.5 Adc, tp = 3 Duty Cycle ≤ 2%, VBE  amped (Table 1)  (IC(pk) = 2 A, 181 = 0.5 Adc, VBE(off) = 5.0 Vdc,	= 2 A, 30 μs, E(off) =	5.0 Vdc)	VBE(sat	todarys todarys todarys todarys todarys todarys todarys todarys todarys	30 Sept.	0.03 0.10 0.40 0.175	2.0 1.5 1.5 0.05 0.40 1.50 0.50	and Market Sensor Senso
(IC = 3 Adc, IB (IC = 2 Adc, IB (IC = 2 Adc, IB IC	= 0.5 Adc, TC = 100° ( ation Voltage = 0.5 Adc) = 0.5 Adc, TC = 100° C)  ACTERISTICS ble 1)  (VCC = 250 Adc, IC = IB1 = 0.5 Adc, Ip = 3 Duty Cycle ≤ 2%, VBE  amped (Table 1)  (IC(pk) = 2 A, IB1 = 0.5 Adc,	= 2 A, 30 μs, E(off) =	5.0 Vdc)	td tr ts tf tc tfi tsv	todarys  tod	30 Sept.	0.03 0.10 0.40 0.175 0.70 0.28 0.15	2.0 1.5 1.5 0.05 0.40 1.50 0.50 2.0 0.50	AMUNIX AF

Reuc

for Soldering Purposes: 1/8" from Case for 5 Seconds



#### **SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS**

The BUS 46P transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. It is particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

100 ns Inductive Fall Time - 25°C (Typ) 150 ns Inductive Crossover Time - 25°C (Typ)

400 ns Inductive Storage Time - 25°C (Typ)

Operating Temperature Range -65 to +150°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents



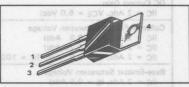
#### 5 AMPERES

#### NPN SILICON **POWER TRANSISTORS**

450 VOLTS 80 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries - are given to facilitate "worst case" design.





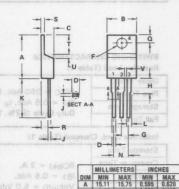
#### **MAXIMUM RATINGS**

Rating	Symbol	BUS 46P 450		Unit
Collector-Emitter Voltage	VCEO(sus)			Vdc
Collector-Emitter Voltage	VCEV		850	Vdc
Emitter Base Voltage	VEB	b7	6	Vdc
Collector Current - Continuous - Peak (1)	IC ICM	82	5 8 (abV	Adc
Base Current - Continuous - Peak(1)	I <sub>B</sub>		2 4	Adc
Total Power Dissipation - T <sub>C</sub> = 25°C - T <sub>C</sub> = 100°C Derate above 25°C	PD	va1 51 1)2	80 9007 =	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	ve1 - 65	to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>Ð</sub> JC	1.56	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

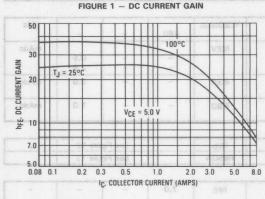
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

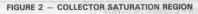


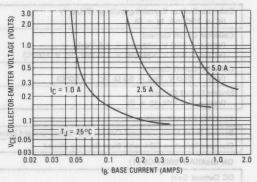
PIN 1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR

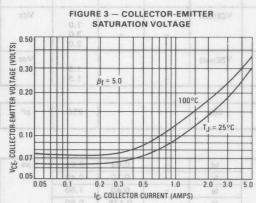
CASE 221A-02 TO 220

	Characteristic		Symbol	Min	Тур	Max	Uni
OFF CHARACTERIS	STICS (1)	Fil	69	AD THERRU	E1 - BC C	RUOFI	
Collector-Emitter S	ustaining Voltage (Table 1) B = 0)	20 20	VCEO(sus)	450	IIII	L	Vdd
Collector Cutoff Current (VCEV = 850 V, VBE(off) = 1.5 Vdc) (VCEV = 850 V, VBE(off) = 1.5 Vdc, TC = 100°C)		ICEV	PIET		0.5 2.5	mAd	
Collector Cutoff Cu		0.0 %	ICER	11-11		3.0	mAd
Emitter Cutoff Curr (VEB = 6.0 Vdc		- C.O. G.S C.O C.	IEBO	- VO	g = 30Å	1.0	mAd
SECOND BREAKDO	OWN	Ho E B					111"
Second Breakdown	Collector Current with Base	Forward Biased	IS/b		See Fig	ure 12	7.8
Clamped Inductive	SOA with Base Reverse Bias	ed	RBSOA		See Fig	gure 13	11.
ON CHARACTERIS	STICS (1)	6.5 0.02 6.8	0.0 0.0	0.0 0.1	3 0.5	0.2 0.1	0 800
DC Current Gain (IC = 3.0 Adc, )	VCE = 5.0 Vdc)		hFE	7.0	0 M01032300 Q	-	-
Collector-Emitter S (IC = 3.0 Adc, I (IC = 5.0 Adc, I	B = 0.6 Adc) B = 1.0 Adc)	TITOS r	VCE(sat)	MS-ROTOS SOATLOVI	13 COLL ATURATION	1.0 3.0 2.0	Vd
(IC = 3.0 Adc, IB = 0.6 Adc, TC = 100°C)  Base-Emitter Saturation Voltage (IC = 3.0 Adc, IB = 0.6 Adc)			VBE(sat)			1.5	Vd
	B = 0.6 Adc, TC = 100°C)	91 8			3s = 5.0"	1.5	l lar
DYNAMIC CHARA	CTERISTICS	11. 9	M	enor			20
Output Capacitano (VCB = 10 Vdc	e, IE = 0, ftest = 100 Khz)	村 夏 十	Cob	VIII		250	pF
SWITCHING CHAR Resistive Load (Ta		38.88					1981
Delay Time			td		0.03	0.05	μ
Rise Time	(VCC = 250 Adc, IC = 3		tr	11211	0.10	0.40	80.0
Storage Time	IB1 = 0.4 Adc, tp = 30 Duty Cycle ≦ 2%, VBE(or		ts	ORACO TARRES	0.40	1.50	69.0
Fall Time	Daty Oyolo II I NY TBE(O	117 0.0 1007	tf	-	0.175	0.50	
Inductive Load, Cla	amped (Table 1)						
Storage Time	FIGURE 6 - CAPA		tsv	HOTUS RO	0.70	8 2.0	μя
Crossover Time	(IC(pk) = 3.0 A,	$(T_J = 100^{\circ}C)$	tc	-	0.28	0.50	- Per
Fall Time	IB1 = 0.4 Adc,	TE M	tfi	17.	0.15	0.30	
Storage Time	VBE(off) = 5.0 Vdc, VCE(pk) = 250 V)	17	tsv	1	0.40	-	001
Crossover Time	ОС(рк)	(T <sub>J</sub> = 25°C)	tc	17-7	0.15	81 - 15	
Fall Time		1 2	tfi	1	0.10	-	0
(1) Pulse Test: PV	W = 300 μs, Duty Cycle ≤ 2	2%.					
$\beta f = \frac{IC}{IB}$				-	1 34		
IB							
			- V 085 - 350 V				
				The same	305		

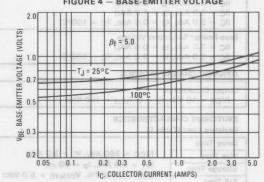


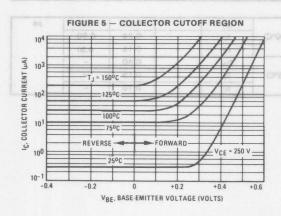




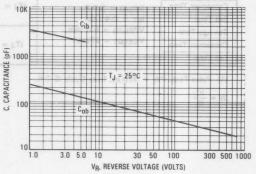


#### FIGURE 4 - BASE-EMITTER VOLTAGE





#### ${\bf FIGURE}~{\bf 6}-{\bf CAPACITANCE}$

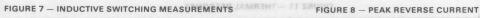


RESISTIVE SWITCHING VCEO(sus) RBSOA AND INDUCTIVE SWITCHING 0.02 μF 100 H.P. 214 or Equiv. 2N6191 P.G. 20 ¥ 10 µF TURN ON TIME ₹RB1 OA I CONDITIONS ₹R<sub>B2</sub> 木 0 02 µF -02 IB1 adjusted to 1.0 µF **₹** 50 obtain the forced +)+ 2N5337 he desired TURN OFF TIME \$ 500 PW Varied to Attain Use inductive switching IC = 100 mA guarantind at 100°C. 100 the resistive test circuit. Adjust R1 to obtain IB1 For switching and RBSOA, R2 = 0 For BVCEO(sus), R2 = 0 FIGURES CIRCUIT Lcoil = 180 µH V<sub>CC</sub> = 250 V R<sub>L</sub> = 83 Ω Pulse Width = 10 μs Lcoil = 80 mH VCC = 10 V V<sub>clamp</sub> - 250 V R<sub>B</sub> adjusted to attain desired I<sub>B1</sub> R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V R<sub>coil</sub> = 0.7 Ω INDUCTIVE TEST CIRCUIT **OUTPUT WAVEFORMS** RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to CIRCUITS RL TUT t<sub>1</sub> ≈ L<sub>coil</sub>(IC<sub>pk</sub>) Vcc 1N4937 11-Lcoil (ICpk) Equivalent TEST

1-12-

VCE

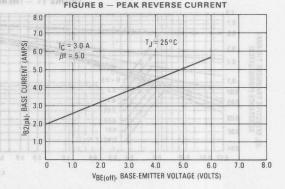
TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



= 0 Rs = 0 0.1 Ω

**Detailed Conditions** 

VCE(pk) 90% VCE(pk) 90% IC(pk) VCE-10% VCE(pk) 10% IC pk 90% IB1 IR-TIME



Test Equipment

Scope - Tektronix 475 or Equivalent

#### SOMAMBORRES SWITCHING TIMES NOTE BET - TREBAT

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

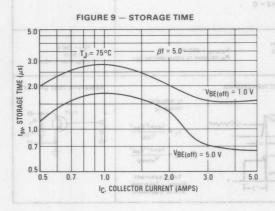
PSWT = 1/2 VCCIC(tc)f

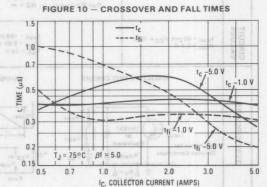
In general,  $t_{\text{TV}} + t_{\text{fi}} \cong t_{\text{C}}$ . However, at lower test currents this relationship may not be valid.

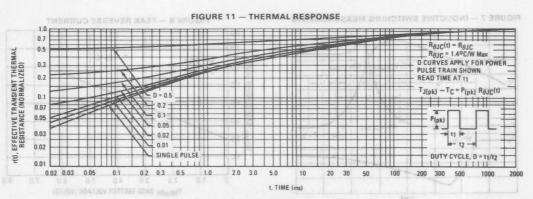
As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $\{t_{\text{C}} \text{ and } t_{\text{SV}}\}$  which are guaranteed at  $100^{\circ}\text{C}$ .

#### INDUCTIVE SWITCHING



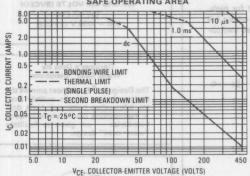




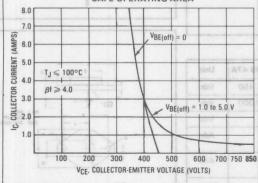


MOTOROLA

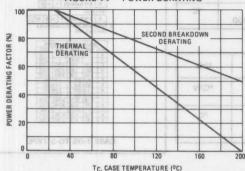
FIGURE 12 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA



## FIGURE 13 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



#### FIGURE 14 - POWER DERATING



#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J</sub>(p<sub>k</sub>) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle S 10%



# SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

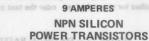
The BUS 47 and BUS 47A transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time – 25°C (Typ)
120 ns Inductive Crossover Time – 25°C (Typ)

Operating Temperature Range -65 to +200°C 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents (125°C)



400 AND 450 VOLTS (BVCEO) 150 WATTS 850 - 1000 V (BVCES)

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data – representing device characteristics boundaries – are given to facilitate "worst case" design.



## 3

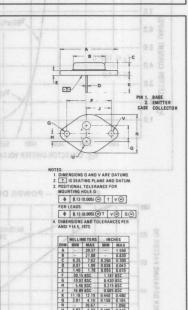
#### **MAXIMUM RATINGS**

Rating Rating	Symbol	BUS 47	BUS 47A	Unit
Collector-Emitter Voltage	VCEO(sus)	450	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB	shapina	7	Vdc
Collector Current — Continuous — Peak (1) — Overload	I <sub>C</sub> M IOI	9 18 99410V 36		Adc
Base Current - Continuous Date Date Date Date Date Date Date Date	. D		5	Adc
Total Power Dissipation $-T_C = 25^{\circ}C$ $-T_C = 100^{\circ}C$ Derate above 25°C	PD	150 85.5 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	0 +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



CASE 1-05 TO-3 TYPE

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	19	Symbol	Min	Тур	Мах	Unit
OFF CHARACTERISTICS (1)	团"。					100
Collector-Emitter Sustaining Voltage (Table 1) (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0) L = 25 mH	BUS47 BUS47A	VCEO(sus)	400 450	-	548	Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc) (VCEV = Rated Value, VBE(off) = 1.5 Vdc, TC	= 125°C)	ICEV		1 to 300	0.15 1.5	mAdc
Collector Cutoff Current (VCE = Rated VCEV, RBE = 10 Ω)	T <sub>C</sub> = 25°C T <sub>C</sub> = 125°C	ICER			0.4 3.0	mAdc
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0)	23.95	IEBO	-		0.1	mAdc
Emitter-base breakdown Voltage (I <sub>E</sub> = 50 mA - I <sub>C</sub> = 0)	j <sub>10</sub>	BVEBO	7.0	11111		Vdc

#### SECOND BREAKDOWN

Second Breakdown Collector Current with Base Forward Biased	Is/b	See Figure 12	
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 13	FOURS 3

#### ON CHARACTERISTICS (1)

DC Current Gain		hFE				
(I <sub>C</sub> = 6 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 5 Adc, V <sub>CE</sub> = 5 V)	BUS47 BUS47A		7	-		
Collector-Emitter Saturation Voltage		VCE(sat)				Vdc
(I <sub>C</sub> = 6 Adc, I <sub>B</sub> = 1.2 Adc)			27 NO.		1.5	1.34
(I <sub>C</sub> =9 Adc, I <sub>B</sub> =1.8 Adc)	BUS47	HINT COLUMN	11-175		5.0	0.5
(I <sub>C</sub> =6 Adc, I <sub>B</sub> =1.2 Adc, T <sub>C</sub> =100°C)	THE RESERVE	HEED LICE	114111	2005 -	2.5	-
(Ic = 5 Adc, Ig = 1 Adc)			3.001 - 5	17-11	1.5	
(Ic = 8 Adc, Ig = 1.6 Adc)	BUS47A	White the feet			5.0	1.0
(IC = 5 Adc, IB = 1 Adc, TC = 100°C)			4	- 1	2.5	70.0
ase-Emitter Saturation Voltage	- 0	VBE(sat)				Vdc
(IC = 6 Adc, IB = 1.2 Adc)	BUS47				1.6	1
(I <sub>C</sub> = 6 Adc, I <sub>B</sub> = 1.2 Adc, T <sub>C</sub> = 100°C)	00347	HUMBET I I	141	- 1	1.6	
(Ic = 5 Adc, Ig = 1 Adc)	DUCATA	rie .	ni-	P - 1	1.6	1.0
(I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1 Adc, T <sub>C</sub> = 100°C)	BUS47A	95			1.6	

#### DYNAMIC CHARACTERISTICS

Output Capacitance	Cob	# ########	COLLECTOR	PROUNE S	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 Khz)		-	-	300	
	I KYK	-	7 7		1.901

### SWITCHING CHARACTERISTICS

#### Resistive Load (Table 1)

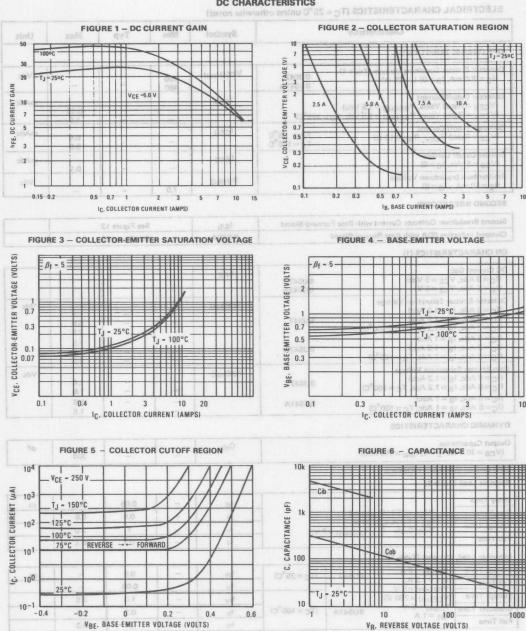
Delay Time		td	11-1	0.05	0.2	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 6 A, I <sub>B1</sub> = 1.2 A, t <sub>p</sub> = 30 μs, Duty Cycle 2 , V <sub>BE(off)</sub> = 5 V)	tr	VZ	0.5	0.8	
Storage Time		ts	M-I	1	2.0	- 0
Fall Time	tf	1 - 10	0.2	0.4	1	

#### Inductive Load, Clamped (Table 1)

Storage Time	(I <sub>C(pk)</sub> = 6 A,	BUS47	BUS47 (T <sub>C</sub> = 25°C)	tsv	NI-1	0.9	L	μs
Fall Time	I <sub>B1</sub> = 1.2 A, V <sub>BE(off)</sub> = 5 V,	50347	tfi	1	0.06	- 200	9	
Storage Time	VCE(c1) = 250 V)			t <sub>sv</sub>	1-1	1.0	2.5	
Crossover Time	IC(pk) = 5 A	BUS47A	(T <sub>C</sub> = 100°C)	tc	- 5.0	0.2	0.5	1.0-
Fall Time	I <sub>B1</sub> = 1 A			tfi	OLYAGE IVESTS	0.1	0.3	

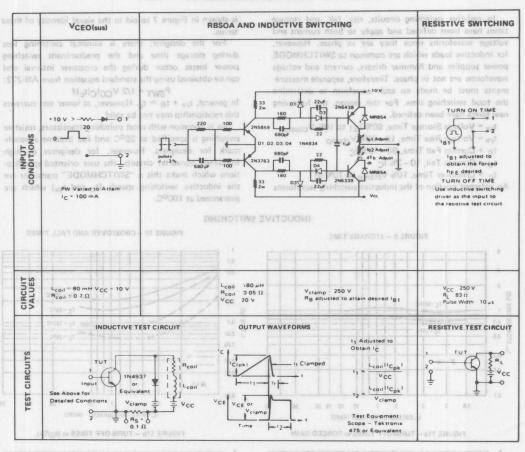
<sup>(1)</sup> Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

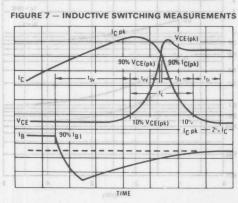
#### DC CHARACTERISTICS

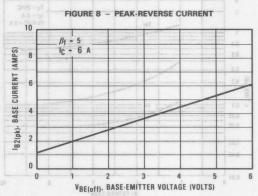


3-550

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE







#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

tc = Crossover Time, 10% Vclamp to 10% IC

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv} + t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING

FIGURE 9 - STORAGE TIME

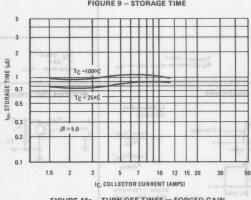


FIGURE 11a - TURN-OFF TIMES vs FORCED GAIN

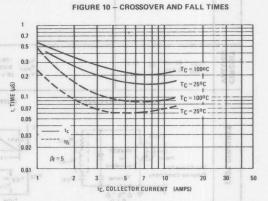
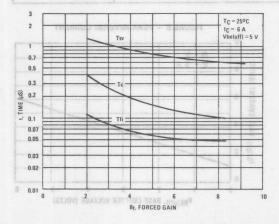
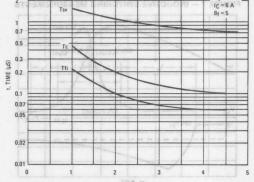
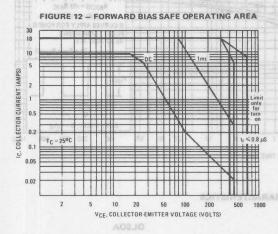


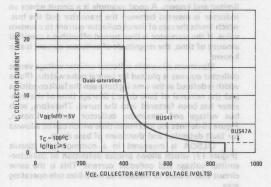
FIGURE 11b - TURN-OFF TIMES vs lb2/lb1



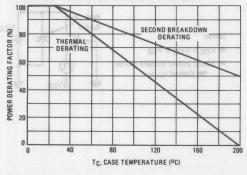




#### FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA



#### FIGURE 14 - POWER DERATING



#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

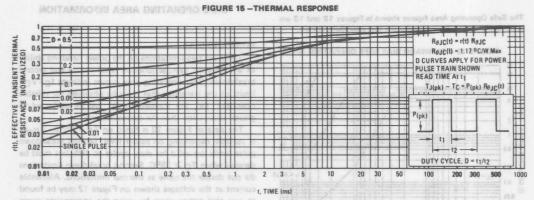
The data of Figure 12 is based on  $T_C=25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J(pk)</sub> may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

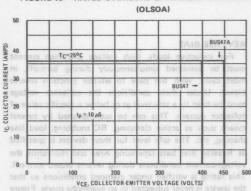
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.





#### **OVERLOAD CHARACTERISTICS**

#### FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA



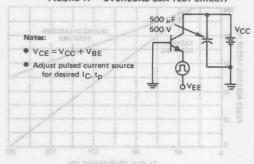
#### OLSOA

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 17) which allows precise definition of collectoremitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

FIGURE 17 -- OVERLOAD SOA TEST CIRCUIT





# SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The BUS 47P/BUS 47AP transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time – 25°C (Typ)
120 ns Inductive Crossover Time – 25°C (Typ)

Operating Temperature Range -65 to +175°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents (125°C)

#### **MAXIMUM RATINGS**

Rating	Symbol	BUS 47P	BUS 47AP	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB		7	Vdc
Collector Current — Continuous — Peak (1) — Overload	I <sub>C</sub>	9 18 36		Adċ
Base Current - Continuous - Peak (1)	I <sub>B</sub>	5 10		Adc
Total Power Dissipation $-T_C = 25^{\circ}C$ $-T_C = 100^{\circ}C$ Derate above 25°C	PD	128 64.5 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +175		°C

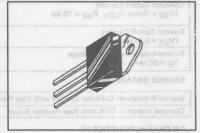
#### THERMAL CHARACTERISTICS

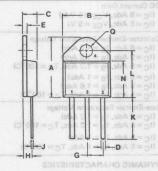
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Reuc	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes:	ΤL	275	10° 901 = 0T
1/8" from Case for 5 Seconds		413	

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle  $\leq$  10%.

# 9 AMPERES NPN SILICON POWER TRANSISTORS

400 AND 450 VOLTS (BVCEO) 128 WATTS 850 - 1000 V (BVCES)





STYLE 1:

1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

DIM	MILLIN	ETERS	INCHES					
	MIN	MAX	MIN	MAX				
A	20.32	21.08	0.800	0.830				
В	15.49	15.90	0.610	0.626				
C	4.19	5.08	0.165	0.200				
D	1.02	1.65	0.040	0.065				
E	1.35	1.65	0.053	0.065				
G	5.21	5.72	0.205	0.225				
Н	2.41	3.20	0.095	0.126				
J	0.38	0.64	0.015	0.025				
K	12.70	15.49	0.500	0.610				
L	15.88	16.51	0.625	0.650				
N	12.19	12.70	0.480	0.500				
0	3.94	4.19	0.155	0.165				

CASE 340-01 TO-218AC



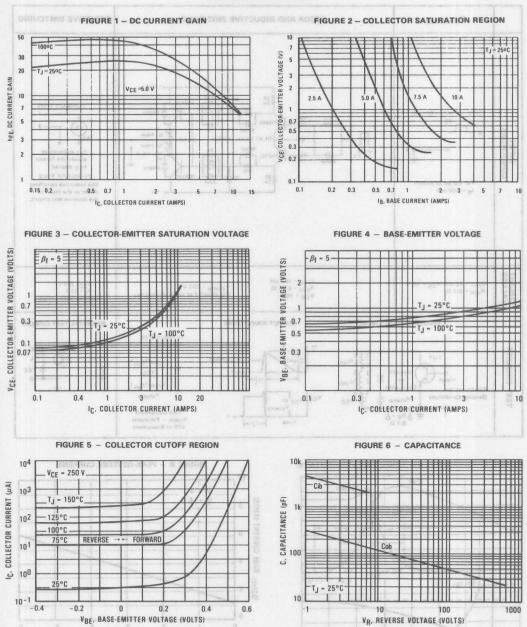
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle \$ 10%.

ELECTRICAL CHARACTER	STICS (TC = 25	5°C unless otherwise r	noted)
----------------------	----------------	------------------------	--------

	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTER	HISTICS (1)	8	нотакам	ART HEV	ON POV	JUNE BILLIC	4
Collector-Emitter Sustaining Voltage (Table 1) (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0) L = 25 mH		BUS47P BUS47AP	VCEO(sus)	400 450	IS ATAP	aus 47P/8	Vdc
Collector Cutoff Cu (VCEV = Rated V (VCEV = Rated V	wrent Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_{C} = 1$	-Malleys be 25°C)	ICEV	of botics yis	re particula	0.15 1.5	mAdc
Collector Cutoff Cu (V <sub>CE</sub> = Rated V <sub>C</sub>	rrent EV, RBE = 10 Ω)	T <sub>C</sub> = 25°C T <sub>C</sub> = 125°C	ICER		- 81	0.4	mAdc
Emitter Cutoff Cur (VEB = 5 Vdc, IC		0-10-	IEBO	_	Drivars	vsls7 <sub>0.1</sub> na b	mAdc
Emitter-base breakd			BVEBO	7.0	-	Controls ion Circuits	Vdc
SECOND BREAKD	OOWN		-	-25°C (Typ.	Fall Time	Off Times ins Inductive	Past Turn 60
Second Breakdown	Collector Current with Base Forv	vard Biased	Is/b	Time-259	See Figure 1:	2vitoubol an	121
Clamped Inductive	SOA with Base Reverse Biased		RBSOA		See Figure 1	3	
ON CHARACTERI	STICS (1)		3	0) 1 4 01 00		remperature riomanca Si	
DC Current Gain (I <sub>C</sub> = 6 Adc, V <sub>CE</sub> (I <sub>C</sub> = 5 Adc, V <sub>CE</sub>	= 5 Vdc) = 5 V)	BUS47P BUS47AP	hFE 80	so.l eviroubr	I milw ADI ubni miw sug	nsa-Biosed Johing Times ration Volta	Revi Swil Sets
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 6 Adc, I <sub>B</sub> = 1.2 Adc) (I <sub>C</sub> = 9 Adc, I <sub>B</sub> = 1.8 Adc) (I <sub>C</sub> = 6 Adc, I <sub>B</sub> = 1.2 Adc, T <sub>C</sub> = 100 °C) (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1 Adc) (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1.6 Adc)		BUS47P	VCE(sat)		(0 051) 8	1.5 5.0	Vdc
		BUS47AP	NUS 47P BU	T lodfiivit T	-	2.5 1.5 5.0	A MUMIX.
	1 Adc, T <sub>C</sub> = 100°C)	200 7619 0	NO THEODY	80034169		2.5	
Base-Emitter Saturation Voltage (IC = 6 Adc, Ig = 1.2 Adc) (IC = 6 Adc, Ig = 1.2 Adc, TC = 100°C) (IC = 5 Adc, Ig = 1 Adc) (IC = 5 Adc, Ig = 1 Adc) (IC = 5 Adc, Ig = 1 Adc)		BUS47P 000	V <sub>BE(sat)</sub>	VOEO(sus)	_	1.6	Vdc
		BUS47AP	7	82/	-	1.6 1.6	tter Base Vo
DYNAMIC CHARA	CTERISTICS		38	lcw.		- Prink (1) - Overland	
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I	E = 0, f <sub>test</sub> = 100 Khz)	20.4	Cob	85 MB1	-	300	pF
SWITCHING CHAP	RACTERISTICS	asseW	128	1 09		sipation - To	al Power Dis
Resistive Load (Tab			0.86				
Delay Time	XAM WWW MIG	30	td	1 . = . 7	0.05	0.2	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 6 A,	75	to tr	- Otal - 1	0.5	0.8	erufsiogme
Storage Time	$I_{B1} = 1.2 \text{ A, } t_p = 30 \mu \text{s,}$ Duty Cycle $\leq 2\%$ , $V_{BE(off)} = 2\%$	=5 V)	ts	_	1	2.0	
Fall Time	2 /0, BE(011)	.,	tf	-	0.2	0.4	ERMAL CH
Inductive Load, Cla	mped (Table 1)	ainU	schi	Symbol		obsheroesen	
Storage Time (1)	Class = 6.A	(T25°0)	t <sub>sv</sub>		0.9	_	μς
11	IB1 = 1.2 A, VBE(off) = 5 V, VCE(c1) = 250 V)	(T <sub>C</sub> = 25°C)	tfi	Stall	0.06	- 000	mal Necista ction to Cas
			t <sub>sv</sub>		1.0	2.5	
V		(T <sub>C</sub> = 100°C)	t <sub>c</sub>	37	0.2	0.5	best mumb
					0.1	0.3	Soldering Pu 8" from Ca

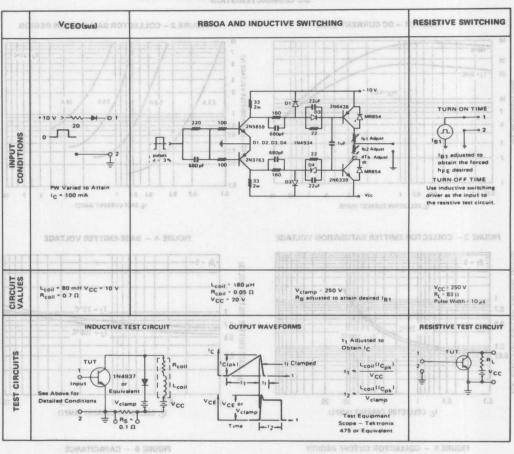
<sup>(1)</sup> Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

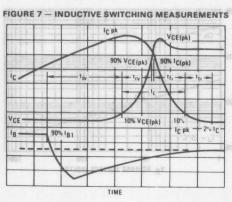
#### DC CHARACTERISTICS

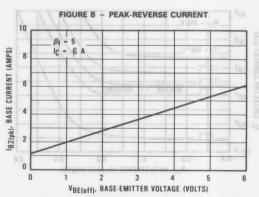


3

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE







The Safe Operating Area figures shown

#### MORTAMROPMI ABRA DIRITARBRO BRASWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

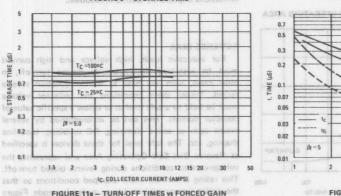
PSWT = 1/2 VCCIC(tc)f

In general, try + tfi = tc. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are quaranteed at 100°C.

# art hert are souler at beloned ad neo tert INDUCTIVE SWITCHING

FIGURE 10 - CROSSOVER AND FALL TIMES FIGURE 9 - STORAGE TIME



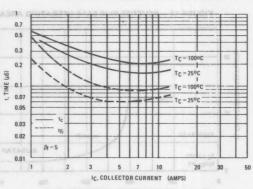
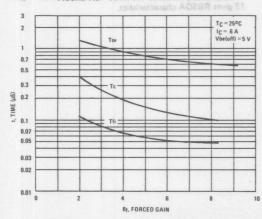
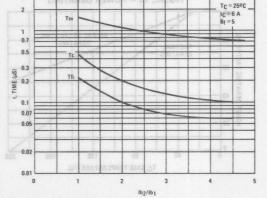


FIGURE 11b - TURN-OFF TIMES vs lb2/lb1





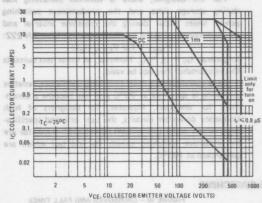


FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA

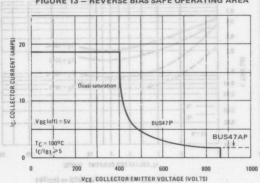
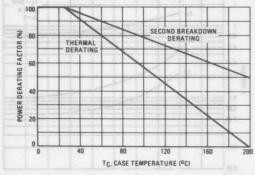


FIGURE 14 - POWER DERATING



#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

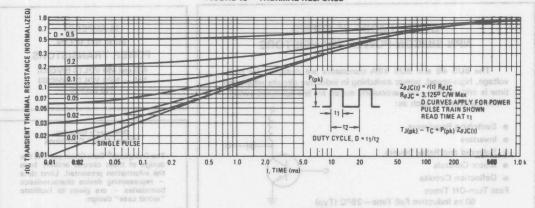
T<sub>J</sub>(p<sub>k</sub>) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.

3

FIGURE 15 - THERMAL RESPONSE



#### **OVERLOAD CHARACTERISTICS**

FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA



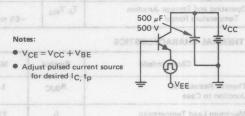
## OLSOA OCO

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus. which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 17) which allows precise definition of collectoremitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

FIGURE 17 - OVERLOAD SOA TEST CIRCUIT



The BUS 48 and BUS 48A transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

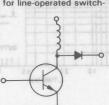
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time – 25°C (Typ) 120 ns Inductive Crossover Time – 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:
Reverse-Biased SOA with Inductive Loads
Switching Times with Inductive Loads
Saturation Voltages
Leakage Currents (125°C)



3

## MAXIMUM RATINGS to shadingsmade, smit to shuome

Rating	Symbol	BUS 48	BUS 48A	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB	Dus vo	7	Vdc
Collector Current — Continuous — Peak(1) — Overload	ICM IOL	4	15 30 60	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	emitter sirouit	5	Adc
Total Power Dissipation - T <sub>C</sub> = 25°C - T <sub>C</sub> = 100°C  Derate above 25°C - A C	PD VI SAUDI	1	75 00 .0	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

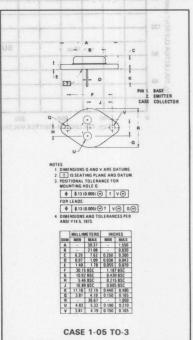
# 15 AMPERES NPN SILICON POWER TRANSISTORS

400 and 450 VOLTS (BVCEO) 850 - 1000 VOLTS (BVCES) 175 WATTS

> Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries — are given to facilitate "worst case" design.



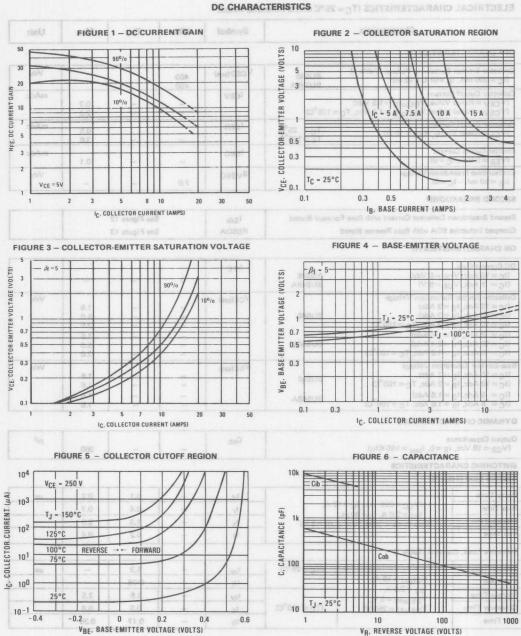


### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

MODER HOTTARITY Characteristic g as up a			Symbol	Min	яш:Тур- г	Max	Unit
OFF CHARACTERIS	STICS (1)	Of 3.	THE STATE OF		11000		
Collector-Emitter Sus (I <sub>C</sub> = 200 mA, I <sub>B</sub> =	staining Voltage (Table 1) 0) L = 25 mH	BUS48 BUS48A	VCEO(sus)	400 450			Vdc
Collector Cutoff Curr (VCEV = Rated Val (VCEV = Rated Val	rent lue, V <sub>BE(off)</sub> = 1.5 Vdc) lue, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub>		ICEV	450	di aros	0.2 2.0	mAdc
Collector Cutoff Curr (VCE = Rated VCE		T <sub>C</sub> = 25°C T <sub>C</sub> = 125°C	ICER			0.5 3.0	mAdc
Emitter Cutoff Curre (V <sub>EB</sub> = 5 Vdc, I <sub>C</sub> =		E 0 0 0	IEBO	-		0.1	mAdc
Emitter-base breakdo (I <sub>E</sub> = 50 mA - I <sub>C</sub> =		3*89 - 57	BVEBO	7.0	-	-	Vdc
SECOND BREAKDO	WN 20 6.0		32 32			2 2	1
Second Breakdown Collector Current with Base Forward Biased Clamped Inductive SOA with Base Reverse Biased			IS/b RBSOA	See Figure 12 See Figure 13			
ON CHARACTERIS	TICS (1)	PIT	RANTON	ROSTARUTA	ENNTTER S	DILECTOR	108E3 - C
DC Current Gain (IC = 10 Adc, VCE (IC = 8 Adc, VCE		BUS48 BUS48A	hFE	8	-	-	- 3-11
	2 Adc) 3 Adc) 2 Adc, T <sub>C</sub> = 100°C)	BUS48	VCE(sat)	1/2/	=	1.5 5.0 2.0	Vdc
(I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1 (I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 1 (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1		BUS48A		= 3		1.5 5.0 2.0	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2 Adc, T <sub>C</sub> = 100°C)  (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1.6 Adc) (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1.6 Adc, T <sub>C</sub> = 100°C)  BUS48A		VBE(sat)	=		1.6 1.6 1.6 1.6	Vdc	
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 Khz)		C <sub>ob</sub>	CPHIALTH	AMENO REFEREN	350	pF	
SWITCHING CHARA Resistive Load (Table	ACTERISTICS	EFF 701	II N	DER TROP	D ROYDE OF	D - 2 384	1,14
Delay Time			t <sub>d</sub>	111	0.1	0.2	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> =		tr	YV	0.4	0.7	
Storage Time	$I_{B1} = 2.0 \text{ A, } t_p = 30 \mu \text{s,}$ Duty Cycle $\leq 2^{\text{O}}/\text{o}$ , $V_{BE(off)} = 5 \text{ V}$		ts	1	1.3	2.0	10
Fall Time			tf	1	0.2	0.4	125
Inductive Load, Clam	pped (Table 1)			->-	UNAWAUN	REVENSE	3°ent t
Storage Time		(T <sub>C</sub> =25°C)	t <sub>sv</sub>	1	1.3		μѕ
Fall Time	(I <sub>C(pk)</sub> = 10 A,		tfi		0.06		0
Storage Time	I <sub>B1</sub> = 2.0 A, V <sub>BE(off)</sub> = 5 V, V <sub>CE(c1)</sub> = 250 V)		t <sub>sv</sub>	1	1.5	2.5	250
Crossover Time		(T <sub>C</sub> = 100°C)	t <sub>C</sub>		0.3	0.6	
9.000010.							

<sup>(1)</sup> Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

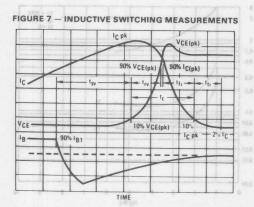


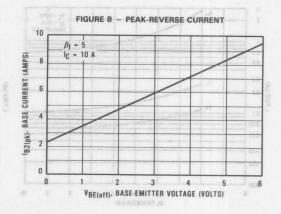


(1) Pulse Tast: PW = 300 yrs, Duty Cycle \$ 2%.

RBSOA AND INDUCTIVE SWITCHING RESISTIVE SWITCHING VCEO(sus) CONDITIONS lb2 Adjust obtain the forced .22uf TURN OFF TIME PW Varied to Attain Use inductive switching IC = 100 mA driver as the input to the resistive test circuit. FIGURE 16 - CROSLOVER AND FALL TIMES FIGURE 9 - STORAGE TIME, TW CIRCUIT  $L_{coil}$  = 80 mH  $V_{CC}$  = 10 V  $R_{coil}$  = 0.7  $\Omega$ L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 250 V R<sub>L</sub> = 83 Ω Pulse Width = 10 μs V<sub>clamp</sub> - 250 V Rg adjusted to attain desired I<sub>81</sub> VCC = 20 V INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT Obtain IC CIRCUITS TUT Lcoil (ICpk Vcc Lcoil (ICpk TEST V<sub>clamp</sub> **Detailed Conditions** VCE Test Equipment Scope - Tektronix 475 or Equivalent 1-12-

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE





# SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

try = Voltage Rise Time, 10-90% Volamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv}$  +  $t_{fi}$   $\simeq$   $t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING

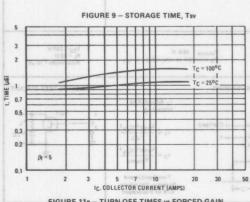


FIGURE 11a - TURN-OFF TIMES vs FORCED GAIN

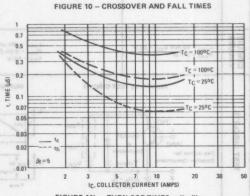
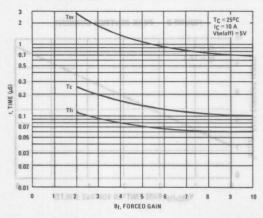
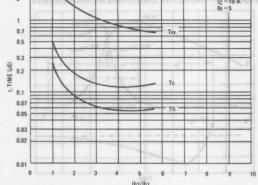
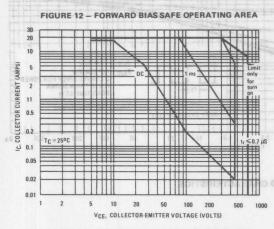


FIGURE 11b - TURN-OFF TIMES vs lb2/lb1





# The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.



#### FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA

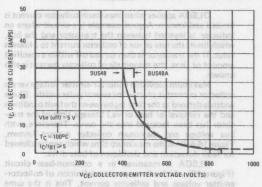
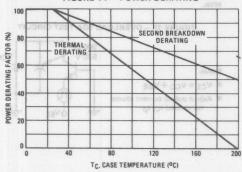


FIGURE 14 - POWER DERATING



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

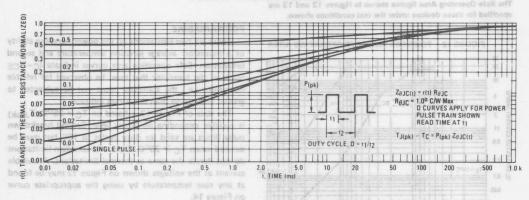
The data of Figure 12 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.

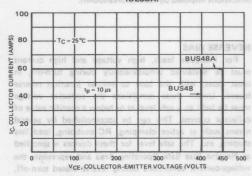




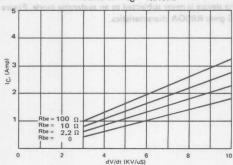
## OVERLOAD CHARACTERISTICS of Very OVERLOAD CHARACTERISTICS

## FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA (OLSOA)

temperatures, thermal limitations will reduce



#### FIGURE 17 - IC = f(dV/dt)



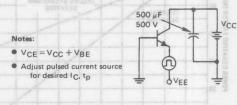
#### FIGURE 12 - RE AOSJONAS SAFE CESTATING AREA

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating

FIGURE 18 - OVERLOAD SOA TEST CIRCUIT



3



#### SWITCHMODE IIA SERIES NPN SILICON POWER TRANSISTORS

The BUS 48P/BUS 48AP transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time - 25°C (Typ) 120 ns Inductive Crossover Time - 25°C (Typ)

Operating Temperature Range - 65 to + 175°C 100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads

Switching Times with Inductive Loads Saturation Voltages

Leakage Currents (125°C)

#### **MAXIMUM RATINGS**

Rating	Symbol	BUS 48P	BUS 48AP	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB		7	Vdc
Collector Current — Continuous — Peak(1) — Overload	I <sub>C</sub> M IOI	15 30 60		Adc
Base Current - Continuous - Peak(1)	I <sub>B</sub>	5 20		Adc
Total Power Dissipation - T <sub>C</sub> = 25°C - T <sub>C</sub> = 100°C Derate above 25°C	PD	150 75 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 t	o +'175	°C

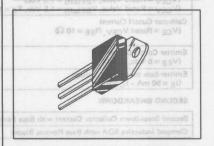
#### THERMAL CHARACTERISTICS

			19.0	
Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	ReJC	1.0	°C/W	
Maximum Lead Temperature for Soldering Purposes:	TL	275	°C	
1/8" from Case for 5 Seconds		2	0°007=3T)	

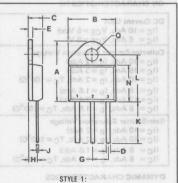
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 15 AMPERES NPN SILICON POWER TRANSISTORS

400 and 450 VOLTS (BVCEO) 850 - 1000 VOLTS (BVCES) 150 WATTS



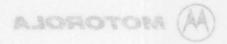
-0



- 1. BASE
- 2. COLLECTOR TOWARD THEFTO
- 3. EMITTER SOV OF = SOV)
- 4. COLLECTOR

	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
0	3.94	4.19	0.155	0.165

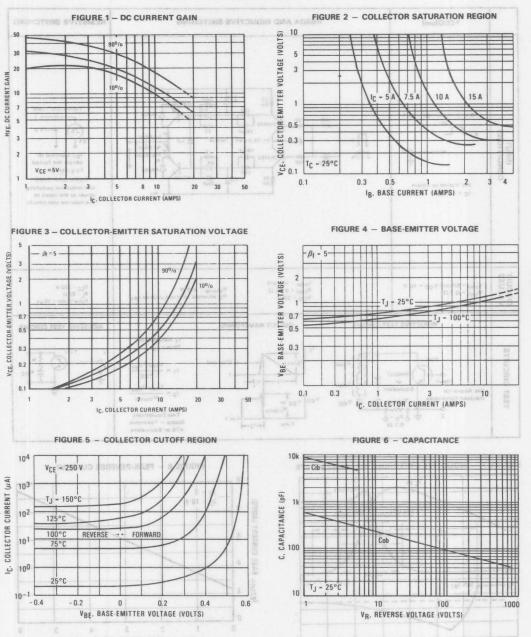
CASE 340-01 TO-218AC

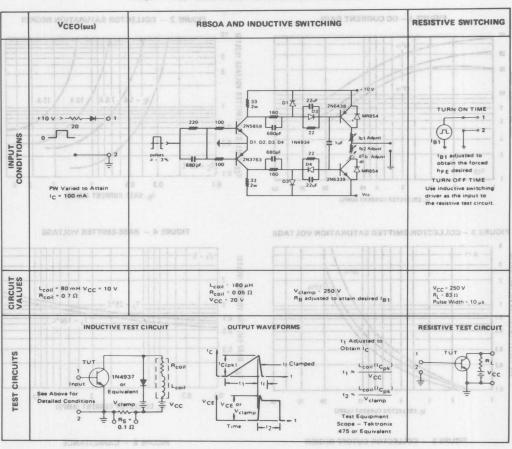


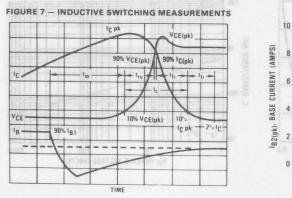
Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)		NSISTOR	ART REW	ON POY	IPN SILIC	N
Collector-Emitter Sustaining Voltage (Table	1) doi: high-	VCEO(sus)	transistore	S 48AP	U8/48# SUS	Vdc
(I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0) L = 25 mH	BUS48P BUS48AP	atiuania avita	400 450	silvæ <del>+</del> swite	igh s <sub>m</sub> ead, po	voltage, l
Collector Cutoff Current	-Hustiwa b	ICEV	pawa da	doubt to u to	the rions suff	mAdc
(V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vd (V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vd		9	_	Ī	0.2	
Collector Cutoff Current		ICER		8	ing Regulation	mAdc
$(V_{CE} = Rated V_{CEV}, R_{BE} = 10 \Omega)$	$T_C = 25^{\circ}C$	5	-	-	0.5	e Inverte
5.: 0 . W.O	T <sub>C</sub> = 125°C			#igizisf3	3.0	a Solena
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0)		LEBO	6 -	-	0.1	mAdc
Emitter-base breakdown Voltage		BVEBO			SHOULD HOL	Vdc
$(I_E = 50 \text{ mA} - I_C = 0)$			7.0	-	semil' 190-	Past Turn
SECOND BREAKDOWN		PC (Typ)			t ny Inductive ny Inductive	
Second Breakdown Collector Current with E	Base Forward Biased	Is/b		See Figure 1		
Clamped Inductive SOA with Base Reverse I	Biased	RBSOA	11 + 01 qq	See Figure 1	13	Deserved
ON CHARACTERISTICS (1)		gha	n Levitoubo	of beidge	rromance Sp erce-Bissed S	100°C Pe
DC Current Gain			Share roads	ubot raw	sour grance	ws
(IC = 10 Adc, VCE = 5 Vdc)	BUS48	PE			station Voltag	
(IC = 8 Adc, VCE = 5 V)	BUS48A		8	(0°8 <u>s</u> t)	age Eurren	86.)
Collector-Emitter Saturation Voltage		VCE(sat)				Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2 Adc) (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 3 Adc)	BUS48P			_	1.5 5.0	EI SOMBREELA
$(I_C = 10 \text{ Adc}, I_B = 2 \text{ Adc}, T_C = 100^{\circ}\text{C})$				<del>-</del>	2.0	er minorial des
(I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1.6 Adc)	BUS48AP	BUS ASP BUS	Symilor	-	1.5	
(I <sub>C</sub> = 12 Adc, I <sub>B</sub> = 2.4 Adc) (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 1.6 Adc, T <sub>C</sub> = 100°C)	BUS46AP	000	Supplement of the second	_	5.0	legion-Eminu
Base-Emitter Saturation Voltage	any pay	V <sub>BE(sat)</sub>	Mensy		anatioV -	Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2 Adc, T <sub>C</sub> = 100°C)	BUS48P	1 200	V92V		1.6	100000000000000000000000000000000000000
(IC = 8 Adc, IB = 1.6 Adc)	Jaby	4	637		1.6	V east tath
(IC = 8 Adc, IB = 1.6 Adc, TC = 100°C)	BUS48AP	15	21	_ 24	1.6	legior Curre
DYNAMIC CHARACTERISTICS		08	101		bsofreyC -	
I. Dakt	- Ada	8	q!		Continuous	- Instru0 si
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 Khz)		Cob	V181		350	pF
#07031/03 /A	Watts	035	- 69	= 25%C =	DI - TRETEGIE	al Power Di
SWITCHING CHARACTERISTICS						
Resistive Load (Table 1)	700					
Delay Time	-101	A or td	Bis. m.	0.1	0.2	μs
( $V_{CC} = 250 \text{ Vdc}, I_{B1} = 2.0 \text{ A}, t_p = 3$		t <sub>r</sub>	-	0.4	0.7	WIN DAY OF THE
Storage Time Duty Cycle 2	VBE(off) = 5 V)	t <sub>s</sub>	-	1.3	2.0	EPWAT CH
Fall Time 3 200.0 SV.2 SV.4		tf	- 1	0.2	0.4	
nductive Load, Clamped (Table 1)	200	Address	Op. High		GO BING FOR THE	
Storage Time	(T <sub>C</sub> = 25°C)	t <sub>sv</sub>	ousin	1.3	,000	μs
Fall Time (I <sub>C(pk)</sub> = 10 A,		tfi		0.06	-	E. J. 15 '00.151
Storage Time I <sub>B1</sub> = 2.0 A,	1 3	t <sub>sv</sub>	3"_ 1	1.5	2.5	ximum Lead
$V_{BE(off)} = 5 \text{ V},$ $V_{CE(c1)} = 250 \text{ V})$	(T <sub>C</sub> = 100°C)	t <sub>c</sub>	_	0.3	0.6	Seldering Pl 18" from Ca
	0	-0		5.0	THE PER CHAPT SE	PLANTING ON

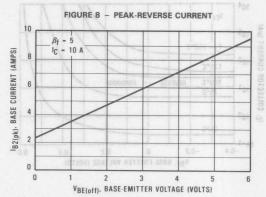
<sup>(1)</sup> Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

#### BOMAMA OR SE DC CHARACTERISTICS OF TRATE IS JEAT









#### MONTAMBORM ASHA DIMITARENO SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

Tu(ok) may be calculated from the data in Figure 11.

try = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90 – 10% I<sub>C</sub>
tti = Current Tail, 10 – 2% I<sub>C</sub>

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general, try + tfi = tc. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

20 50 100 200

# art nart seal seules of belland ed no sen INDUCTIVE SWITCHING

FIGURE 9 - STORAGE TIME, Tsv

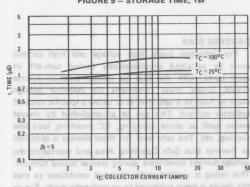


FIGURE 11a- TURN-OFF TIMES vs FORCED GAIN

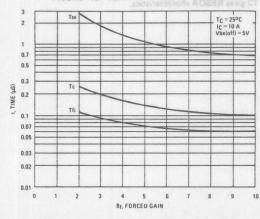


FIGURE 10 - CROSSOVER AND FALL TIMES

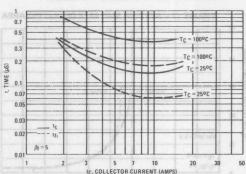
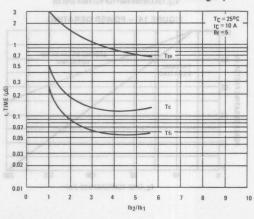


FIGURE 11b - TURN-OFF TIMES vs Ib2/Ib1



#### STOM SANSY SHAPE SAFE OPERATING AREA INFORMATION

The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA

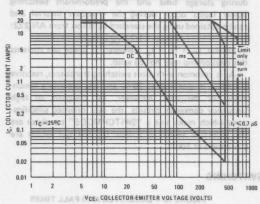


FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA

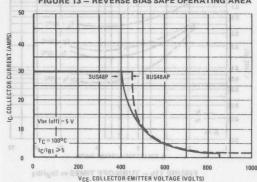
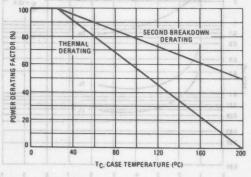


FIGURE 14 - POWER DERATING



# In resistive switching circuits, rise, fall, and storage nes have been defined and apply to be SAIB DRAWROF

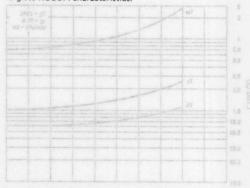
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C=25^{o}C$ ;  $T_{J}(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

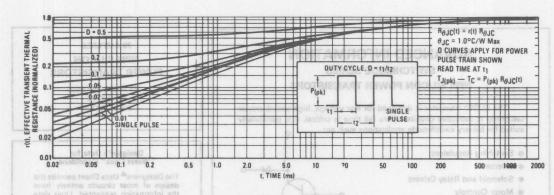
#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.



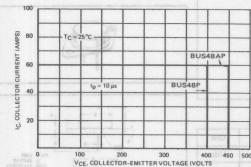
3

FIGURE 15 - THERMAL RESPONSE

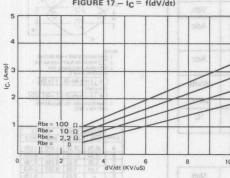


#### **OVERLOAD CHARACTERISTICS**

#### FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA (OLSOA)



#### FIGURE 17 - IC = f(dV/dt)



#### Operating Temperatur AOSJO 65 to +200°C

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

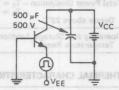
OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collectoremitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

#### FIGURE 18 - OVERLOAD SOA TEST CIRCUIT

Notes:

· VCE = VCC + VBE

 Adjust pulsed current source for desired IC, tp



**ADVANCED INFORMATION** 

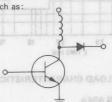
SWITCHMODE SERIES **NPN SILICON POWER TRANSISTORS** 

The BUS50 transistor is designed for low voltage, high-speed, power switching in inductive circuits where fall time is critical. It is particularly suited for battery switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls

Fast Turn-Off Times 300 ns Inductive Fall Time -25°C (Typ)

Operating Temperature Range -65 to +200°C 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents (125°C)



**70 AMPERES** 

#### NPN SILICON **POWER TRANSISTORS**

125 VOLTS (BVCEO) 350 WATTS 200 V (BVCES)

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries - are given to facilitate "worst case" design.



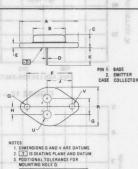
#### MAXIMUM RATINGS

-next sets to se Rating and Levisto seed	Symbol	BUS50	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	125	Vdc
Collector-Emitter Voltage	V <sub>CEV</sub>	200	Vdc
Emitter Base Voltage	VEB	0 7	Vdc
Collector Current – Continuous – Peak (1) – Overload	I <sub>C</sub> I <sub>CM</sub> I <sub>ol</sub>	70 140	Adc
Base Current – Continuous – Peak (1)	I <sub>B</sub>	20	Adc
Total Power Dissipation $-T_C = 25^{\circ}C$ $-T_C = 100^{\circ}C$ Derate above 25°C	P <sub>D</sub>	350 200 2	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>eJC</sub>	0.5	°C/W
Maximum Lead Temperature for Soldering Purposes: %" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≦ 10%.



♦ 0.13 (0.005) W T V W FOR LEADS

♦ 0.13 (0.005) @ T V @ Q @ DIMENSIONS AND TOLERANCES ANSI Y14.5, 1973.

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 1-05 TO-3 TYPE



#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit.	
OFF CHARACTERISTICS <sup>1</sup>					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)		V <sub>CEO(sus)</sub>	125		Vdc
Collector Cutoff Current at Reverse Bias: $(V_{CE}=200 \text{ V}, V_{BE}=-1.5 \text{ V})$ $(V_{CE}=200 \text{ V}, V_{BE}=-1.5 \text{ V}, T_{C}=125^{\circ}\text{C})$		ICEX	ED INFO	.2	mAdd
Collector-Emitter Cutoff Current (V <sub>CE</sub> = 125 V)		ICEO AMAT	REWOS M	MEN SITTED	mAdd
200 and 250 VOLTS (BVCSO)	diage, high-	v woi rol banglesb	ns anothierich	SUSSI and BUSS2	edT
Emitter Cutoff Current (V <sub>FR</sub> = 7 V)	virtical. They	al emit leso vertir al		in a goldatiwa rewo	mAdd
Designer's Deta for				stotslugsR pnid	s Switch
"Worst Case" Cenditions The Designers <sup>A</sup> Data Sheet germits the	0 15				e Invers e Solen
ON CHARACTERISTICS¹  DC Current Gain  (Io = 5 A Vor = 4 V)	0 16	h <sub>FE</sub>	20	ers oid and Relay Driver Controls 1-Off Times	Invent     Solen     Motor     Fast Turn
ON CHARACTERISTICS <sup>1</sup>	0-16	h <sub>FE</sub>	20 15	ers pid and Relay Driver Controls	Moton Solen

#### SWITCHING CHARACTERISTICS (Resistive Load) ton and (Inductive Load) tsv, tfi

Turn-on Time			Meserch F	ton	seymmen	1.2 µs		
Storage Time	$I_C = 70 \text{ A}, I_{B1} = 7 \text{ A} \text{ VBEOT} = -5 \text{ V}$ $(V_{CC} = 125 \text{ V})$		$I_{C} = 70 \text{ A, } I_{B1} = 7 \text{ A}  \text{VBEoff} = -5 \text{ V}$			Total M		a 1.5 to V ration Hypothesis
Fall Time	$(V_{CC} = 125 \text{ V})$		250	t <sub>fi</sub>		.3		
1713		Vdc	085	300	VCEV	lector-Emitter Voltage		
		Vde		7		litter Base Voltage		
Pulse Test: Pulse Wi	dth ≤ 300 μs, Duty Cycle ≤ 2 %					lector Current - Continuous - Peak (1)		

Collector Current – Continuous – Peak (1) – Overland			
	el mel	01	
Total Power Dissipation – $T_C = 28^{\circ}C$ $-T_C = 100^{\circ}C$			Watts W/°C
Operating and Storage Junction Temperature Bangs	T <sub>a</sub> , T <sub>ag</sub>		

(1)	Pulse	Test:	PW	#	300 μs,	Duty	Cycle	≦	2%.

		Symbol	
WY			
3			

# ADVANCED INFORMATION SWITCHMODE SERIES

NPN SILICON POWER TRANSISTORS

The BUS51 and BUS52 transistors are designed for low voltage, highspeed, power switching in inductive circuits where fall time is critical. They are particularly suited for battery switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls

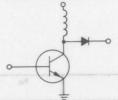
Fast Turn-Off Times 300 ns Inductive Fall Time –25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents (125°C)



#### **MAXIMUM RATINGS**

Rating	Symbol	BUS51	BUS52	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	200	250	Vdc
Collector-Emitter Voltage	V <sub>CEV</sub>	300	350	Vdc
Emitter Base Voltage	V <sub>EB</sub>		7	Vdc
Collector Current – Continuous – Peak (1) – Overload	I <sub>C</sub> I <sub>CM</sub> I <sub>ol</sub>	50 100	40 80	Adc
Base Current – Continuous – Peak (1)	I <sub>B</sub>	10	16	Adc
Total Power Dissipation – $T_C = 25^{\circ}C$ – $T_C = 100^{\circ}C$ Derate above 25°C	P <sub>D</sub>	350 200 2		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>eJC</sub>	0.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

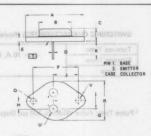
# 50 & 40 AMPERES NPN SILICON POWER TRANSISTORS

200 and 250 VOLTS (BVCEO) 350 WATTS 300-350 (BVCES)

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries are given to facilitate "worst case" design.





- NOTES

  1 DIMENSIONS O AND V ARE DATUMS.
  2 T IS SEATING PLANE AND DATUM.
  3 POSITIONAL TOLERANCE FOR MOUNTING HOLE O

  ↑ \$13 (0.005) T V ○

	MILLIN	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	38.35	39.37	1.510	1.550	
В	19.30	21.08	0.760	0.830	
C	6.35	7.62	0.250	0.300	
D	1.45	1.60	0.057	0.063	
E	-	3.43	-	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
H	5.21	5.72	0.205	0.225	
Ji	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
Q	3.84	4.09	0.151	0.161	
D	24.80	26.67	0.980	1.050	

CASE 1-05 TO-3

e Switching Regulatore

e Mater Controls

· Solenoid and Relay Drivers

e inverters

# M MOTOROLA

#### **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS <sup>1</sup>						
Collector-Emitter Sustaining Voltage (Table 1) (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	BUS51 BUS52	V <sub>CEO(sus)</sub>	200 250			Vdc
Collector Cutoff Current $(V_{CEV} = Rated \ Value, \ V_{BE off)} = 1.5 \ Vdc)$ $(V_{CEV} = Rated \ Value, \ V_{BE off)} = 1.5 \ Vdc, \ T_C = 125^{\circ}C)$	23	I <sub>CEV</sub>	WER TRA	ICON PO	0.2 2.0	mAdc
Collector Cutoff Current (V <sub>CEO</sub> = Rated Value)		I <sub>CEO</sub>		At online h	. ration	mA
	that startive s	sius ils evits	obrii ni gairio	live saviec	basqa rigirl .	voltaga
Emitter Cutoff Current (V <sub>EB</sub> = 7 Vdc, I <sub>C</sub> = 0)	-dothwa bas	I <sub>EBO</sub>	ariy suited s		ent Jesuno enol 2 pilgo	mAdc

#### ON CHARACTERISTICS1

Dosigner's Data for "Worst Case" Conditions

atab para bathauna notumiolni adi			0			
DC Current Gain $(I_C = 5 \text{ Adc}, V_{CE} = 4 \text{ Vdc})$ $(I_C = 50 \text{ Adc}, V_{CE} = 4 \text{ V})$	BUS51	h <sub>FE</sub>	20 15		emiT HO-m	Fast Tu
DC Current Gain $(I_C = 5 \text{ Adc}, V_{CE} = 4 \text{ Vdc})$ $(I_C = 40 \text{ Adc}, V_{CE} = 4 \text{ V})$	BUS52	h <sub>fE</sub>	20 15	tive Crossov	20 ns indus	
Collector-Emitter Saturation Voltage $(I_C = 30 \text{ Adc}, I_B = 2 \text{ Adc})$ $(I_C = 50 \text{ Adc}, I_B = 5 \text{ Adc})$	BUS51	V <sub>CE(sat)</sub>		ure Range Specified f		
(I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2 Adc) (I <sub>C</sub> = 40 Adc, I <sub>B</sub> = 4 Adc)	BUS52		and the second second	d SOA with tes with Indi		
Base-Emitter Saturation Voltage $(I_C=30 \text{ Adc}, I_B=2 \text{ Adc})$ $(I_C=50 \text{ Adc}, I_B=5 \text{ Adc})$	BUS51	V <sub>BE(sat)</sub>			1.8	V <sub>dc</sub>
(I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2 Adc) (I <sub>C</sub> = 40 Adc, I <sub>B</sub> = 4 Adc)	BUS52				1.8	

#### SWITCHING CHARACTERISTICS Resistive Load (Table 1)

1000 RAS	I <sub>C (pk)</sub> = 50 A			t <sub>on</sub>			1	μs			
Turn-on Time	$I_{b1} = 5 A$	BUS51	$(T_C = 25^{\circ}C)$	36	nand.	1000	BITE - Puskel	MO 10136/10			
11-0-	$V_{BE(off)} = 5 V$ $V_{CE (c1)} = 150 V$			08	08	08	80	08 107	be	hinavQ	
	$I_{C (pk)} = 40 \text{ A}$	DUICEO	$(T_C = 100^{\circ}C)$	5	al I		- Continuau	menuO see			
	$- I_{B1} = 4 A $ BUS52	BU552		20	p/al		(1) see9 -				
nductive Load, Cla	amped (Table 1)		strayve	178	qq.	7c = 25°C	- notisquei	newo9 fato			
Storage Time	I <sub>C (pk)</sub> = 50 A		501162	t <sub>sv</sub>		2 001 - 3	2	μѕ			
all Time	$I_{b1} = 5 \text{ A}$ $V_{BE(off)} = 5 \text{ V}$ BUS51	BUS51	$(T_{\rm C} = 25^{\circ}{\rm C})$	t <sub>fi</sub>			.3				
Storage Time	$V_{CE (c1)} = 150 \text{ V}$		00	t <sub>sv</sub>	Die Tate	nonc		perating an			
Crossover Time	I <sub>C (pk)</sub> = 40 A	BUS52	$(T_C = 100^{\circ}C)$	Of Ct <sub>c</sub>			agrish s	Temperatu			

¹ Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%.

Characrarian	Symbol S	esM	
Themsi Rejistance, Junction to Case	DLBB		
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	jī.		



#### SWITCHMODE IIA SERIES NPN SILICON POWER TRANSISTORS

The BUS97 and BUS97A transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time - 25°C (Typ) 120 ns Inductive Crossover Time - 25°C (Typ)

Operating Temperature Range -65 to +200°C 100°C Performance Specified for:

> Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents (125°C)

#### 18 AMPERES NPN SILICON **POWER TRANSISTORS** 450 VOLTS

OFF CHAILACTERISTICS!

175 WATTS

Designer's Data for "Worst Case" Conditions

The Designers<sup>♠</sup> Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.



#### **MAXIMUM RATINGS**

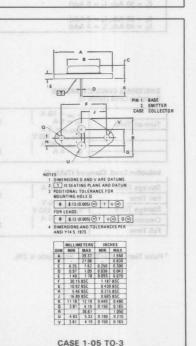
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Rating	Symbol	BUS97	BUS97A	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB		7	Vdc
Collector Current — Continuous — Peak(1) — Overload	I <sub>C</sub> M I <sub>O</sub> L	3	18 30 50	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	:	5	Adc
Total Power Dissipation $-T_C = 25^{\circ}C$ $-T_C = 100^{\circ}C$ Derate above 25°C	PD	1	75 00 .0	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		19.50	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

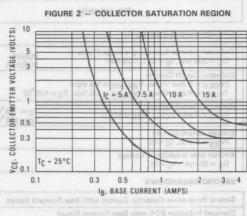


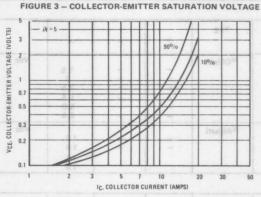
#### **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

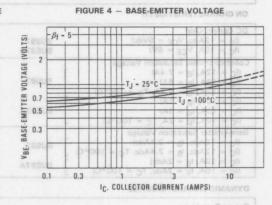
NATION REGION	Characteristic	Symbol	Ao Minas	Тур	Max	Unit
OFF CHARACTE	RISTICS (1)	HHI		I-laine I		
Collector-Emitter S	Sustaining Voltage (Table 1) BUS97 BUS97A	VCEO(sus)	400	HIL		Vdc
Collector Cutoff C (VCEV = Rated V (VCEV = Rated V		ICEV	450	11	0.2	mAdc
Collector Cutoff C (V <sub>CE</sub> = Rated V <sub>C</sub>	urrent $T_C = 25^{\circ}C$ $CEV, R_{BE} = 10 \Omega$ $T_C = 125^{\circ}C$	ICER	<		0.5 3.0	mAdc
Emitter Cutoff Cut (VEB = 5 Vdc, Ic	rrent	IEBO	-		0.1	mAdc
Emitter-base break			7		92=	Vdc
SECOND BREAKE	0.1 65 NWO	20 30 50	87 1	2	1 1	1
Second Breakdown	Collector Current with Base Forward Biased	Is/b	184000 THEAD	See Figure 12		
	SOA with Base Reverse Biased	RBSOA		See Figure 13		
		ATION VOLTAG	BUTAR RE			FIGURE
DC Current Gain		her				
(I <sub>C</sub> = 12Adc, V (I <sub>C</sub> = 10A, V <sub>C</sub> )		PEE	7.	11+		to dy
Collector-Emitter S		VCE(sat)				Vdc
$(I_C = 12A, I_B = I_C = 18A, I_B = I_C = 18A, I_B = I_C = $			1170	11 1	1.5	
	= 2.4A, Tc = 100°C)		37-11	HILL	2.5	
(IC = 10A, IB =			777		1.5	5.0
$(I_C = 15A, I_B =$				d 1 + 1 -	5.0	28 2
	= 2A, T <sub>C</sub> = 100°C) J		- 1/3	NIT	2.5	
Base-Emitter Satu (IC = 12Adc, Ip		VBE(sat)		1337	1.0	Vdc
	BUS97			11235	1.6	\$60 %
(IC = 10A, IB =					1.6	
	= 2Adc, T <sub>C</sub> = 100°C)	books and an archi			1.6	
DYNAMIC CHARA	ACTERISTICS 100 at	65 66 05	DEBAY THERMS	10 0011501100 CI		
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I	E = 0, f <sub>test</sub> = 100 Khz)	Cob	_		350	pF
SWITCHING CHAP	RACTERISTICS	MURDA	a MUSICO A	DESERVICE -	0.2901.01	
Resistive Load (Tab					V D85 - 2	
Delay Time		td	NN	0.1	0.2	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 12A,	tr	1717	0.4	0.7	1 101
Storage Time	l <sub>B1</sub> = 2.4A, t <sub>p</sub> = 30 ès, Duty Cycle ≦ 2%, V <sub>BE(off)</sub> = 5 V)	t <sub>s</sub>	1-1	1.3	2.0	
Fall Time	500, 5,000 = 270, VBE(011) - 3 V)	tf	1-1	0.2	0.4	1 501
Inductive Load, Cla	mped (Table 1)		IONAL	1001 +- 388	13V3A 3°63	
Storage Time				12	3921	- 101
Fall Time	$(I_{C(pk)} = 12A, I_{B1} = 2.4A, $ BUS97 $(T_{C} = 25^{\circ}C)$	t <sub>sv</sub>	-	1.3		μς
	VBE(off) = 5 V,	tfi		0.06		- 00r d
Storage Time	VCE(C1) = 250 V)	t <sub>sv</sub>	-	1.5	2.5	
Crossover Time	$I_{C(PK)} = 10A$ $(T_{C} = 100^{\circ}C)$	t <sub>c</sub>	1 - 1	0.3	0.6	- I - nr
Fall Time	IB1 = 2A II BUS97A	tfi	1.2	0.17	0.35	

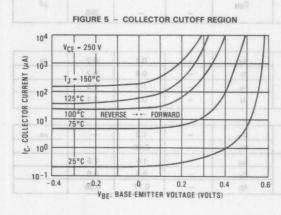
<sup>(1)</sup> Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

FIGURE 1 - DC CURRENT GAIN









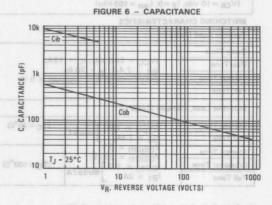
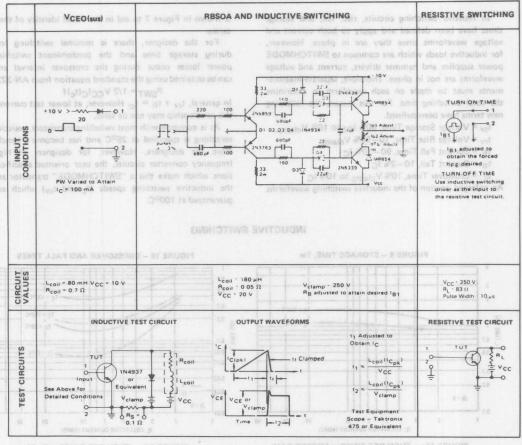
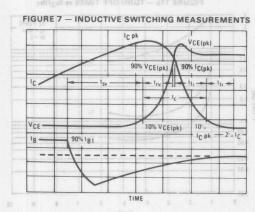
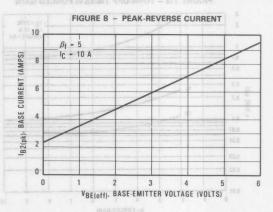


TABLE 1 – TEST CONDITIONS FOR DYNAMIC PERFORMANCE







## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

tc = Crossover Time, 10% Vclamp to 10% IC

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general, trv + tfi = tc. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING



#### FIGURE 10 - CROSSOVER AND FALL TIMES

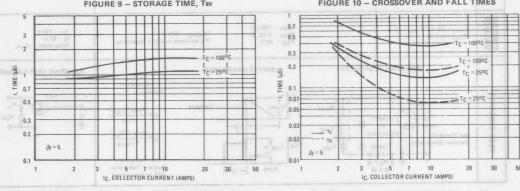
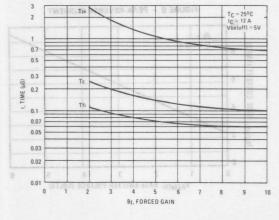
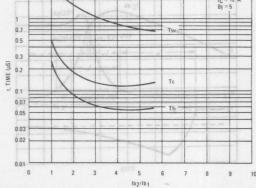


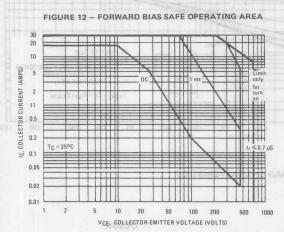


FIGURE 11b - TURN-OFF TIMES vs lb2/lb1

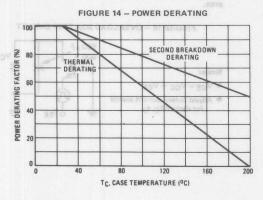




## The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.



#### FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA 50 OCURRENT (AMPS) BUS97 BUS97 COLLECTOR C 20 (חנים שיחיו Vbe (off) = 5 V 10 $T_{C} = 100^{\circ}C$ IC/IB1≥5 1010810 0 200 400 600 800 1000 ONITS TO COLLECTOR EMITTER VOLTAGE (VOLTS)



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

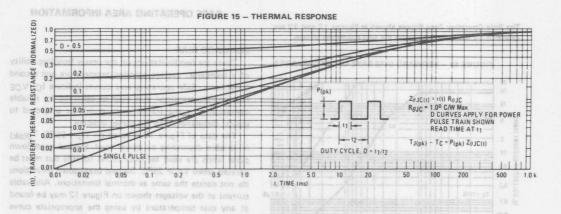
The data of Figure 12 is based on  $T_C=25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

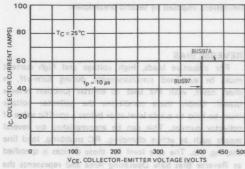
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.



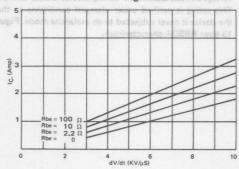


#### OVERLOAD CHARACTERISTICS

## FIGURE 16 - RATED OVERLOAD SAFE OPERATING AREA (OLSOA)



The-most based as FIGURE 17 - IC = f(dV/dt)



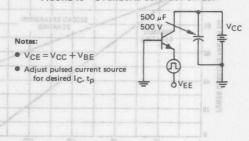
#### OLSOA

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

FIGURE 18 - OVERLOAD SOA TEST CIRCUIT



#### SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The BUS 98 and BUS 98A transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

60 ns Inductive Fall Time - 25°C (Typ) 120 ns Inductive Crossover Time - 25°C (Typ)

Operating Temperature Range - 65 to + 200°C

100°C Performance Specified for :

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents (125°C)

#### **MAXIMUM RATINGS**

Rating	Symbol	BUS 98	BUS98A	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	400	450	Vdc
Collector-Emitter Voltage	VCEV	850	1000	Vdc
Emitter Base Voltage	VEB		7	Vdc
Collector Current — Continuous — Peak (1) — Overload	I <sub>C</sub> I <sub>CM</sub> I <sub>ol</sub>	30 60 120		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		10	Adc
Total Power Dissipation — T <sub>C</sub> = 25°C — T <sub>C</sub> = 100°C Derate above 25°C	P <sub>D</sub>	250 142 1.42		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 t	o + 200	°c

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	0.7	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

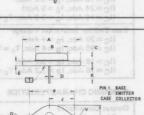
#### 30 AMPERES NPN SILICON POWER TRANSISTORS

400 AND 450 VOLTS (BVCEO) 250 WATTS 850 - 1000 V (BVCES)

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.





DIMENSIONS Q AND V ARE DATUMS.
 To is seating plane and datum.
 Positional tolerance for mounting hole Q:

♦ 13 (0.005) ⊕ T V ⊕ ♦ \$.13 (0.005) @ T V @ Q @

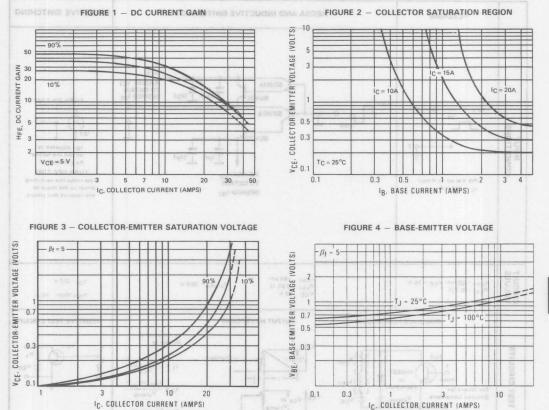
CASE 197-01 MODIFIED TO 3

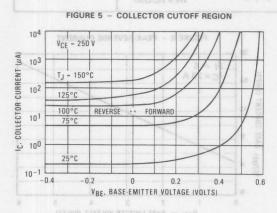


	Characteristic			Symbo	ı	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS (1)			Cyd_i					
Collector-Emitter Su	staining Voltage (Table 1)			VCEO(su	(s)				Vdc
$(I_C = 200 \text{ mA}, I_E)$	3=0) L=25 mH		BUS98 BUS98A		-	400 450	_	Ξ	
Collector Cutoff Cu				ICEV	95 10 5	energy and	SCALING SERVICE		mAdo
(VCEV = Rated )	Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ ) Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ ,	T <sub>C</sub> =125	°C)	CONTROL OF THE CONTRO	100	COM	SMITCH SULFCON I	0.4	
Collector Cutoff Cu	The second control of			ICER	375 734	2000	E12 01240		mAdd
(VCE = Rated V	CEV, R <sub>BE</sub> = 10 Ω)		$T_C = 25$ °C $T_C = 125$ °C		oneiana	- n= A80	and_BUS	1.0	
Emitter Cutoff Curr (V <sub>EB</sub> = 7 Vdc, I <sub>C</sub>			sterity salub detended switte	I EBO	ng ini gr	witchin	ed, power s	0.2	mAdo
Emitter-base breakd	own Voltage	- 100	MAR COTOTAG	VEBO	CO SECO	Attionor	as ribus as:	noirealiges	ohom
(I <sub>E</sub> = 100 mA - I	C=0)		3			7.0			Vdc
SECOND BREAKD	OWN							itching Reg	e Sw
Second Breakdown	Collector Current with Base	Forward	Biased	Is/b			See Fi	gure 12	101 G
Clamped Inductive S	OA with Base Reverse Biase	d	A	RBSOA	1		See Fi	gure 13	M. as
ON CHARACTERIS	TICS(1)								e De
DC Current Gain	100 1000 1000		-	hFE	71 000		100 at 20 at	HT HOHM	285 3
(I <sub>C</sub> = 20 Adc, V <sub>C</sub> (I <sub>C</sub> = 16 Adc, V <sub>C</sub>			BUS98 BUS98A		25 - SI	8	ctive Fall Till ctive Crossor	120 ms India	
Collector-Emitter Sa				VCE(sat	10 + 0	+ 20 -	ature Rance	soms I' pni	Vdc
(IC = 20 Adc, IB	=4 Adc)			OL (Sa	"	-		1.5	0°001
(IC = 30 Adc, IB			BUS98		w I works	tot	Hiw A DS he	3.5	1 001
7999	=4 Adc, T <sub>C</sub> = 100°C)			iva Loads		out evicoupat daine as			
$(I_C = 16 \text{ Adc}, I_B)$ $(I_C = 24 \text{ Adc}, I_B)$			BUS98A		ONO COLUMN S	N. S. A.	/oltaws	1.5 5.0	
(Ic = 16 Adc, IB	= 3.2 Adc, T <sub>c</sub> = 100°C)		B0336A			- (0	runts-(125°)	2.0	
Base-Emitter Saturat		ETT.		VBE(sat	:)				Vdc
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> (I <sub>C</sub> = 20 Adc, I <sub>B</sub>	= 4 Adc) = 4 Adc, T <sub>C</sub> = 100°C)		BUS98		-	_		1.6	
(I <sub>C</sub> = 16 Adc, I <sub>B</sub>						_		1.6	UMIXA
(I <sub>C</sub> = 16 Adc, I <sub>B</sub>	= 3.2 Adc, $T_c = 100^{\circ}C$ )	ried i	BUS98A	an gua	Indoor			1.6	
DYNAMIC CHARA	CTERISTICS			400				nitter Voltage	
Output Capacitance		sbV	1000	Cob	Vesv			gazloV vertin	3 to pF
(V <sub>CB</sub> = 10 Vdc,	$E = 0$ , $f_{test} = 100 \text{ khz}$	Vdc			Vgg	-	-	700	nitter Ban
SWITCHING CHAR Resistive Load (Tabl		abA	100 00						
Delay Time	Philadelina T	strA	1 70	td	181	-	0.1	0.2	μs
Rise Time	$V_{CC} = 250 \text{ Vdc}, I_{C} = 20 \text{ A}$ $I_{R1} = 4.0 \text{ A}, \text{ tp} = 30 \mu \text{s},$		00	t <sub>r</sub>	MBI	-	0.4	0.7	
Storage Time	$I_{B1} = 4.0$ A, $t_{P} = 30$ μs, Duty Cycle $\leq 2\%$ , VBE(off	) = 5 V)	l oa	t <sub>s</sub>	99	-	1.55	non 2.3 10	stel Power
Fall Time	(for BUS98A : I <sub>C</sub> = 16A, Ib	1 = 3.2A	25	tf		-	0.2	0.4	de etate0
Inductive Load, Clar	nped (Table 1)								
Storage Time	lov 11 = 20A 3			t <sub>sv</sub>		- 1	1.55	_	μs
Fall Time	[C(pk) = 20A] (BUS9)	3)	$(T_C = 25^{\circ}C)$	tfi		-	0.06	CHARKE	HERMAI
Storage Time	$V_{BE(off)} = 5 V$			t <sub>sv</sub>	1.0	7	1.8	2.8	
Crossover Time	V <sub>CE(c1)</sub> = 250 V) I <sub>C(pk)</sub> = 16A I <sub>R</sub> = 22A (BUS98	(-	$T_C = 100^{\circ}C$	t <sub>c</sub>	Contract Ann	-	0.3	0.6	
Fall Time	IB1 = 3.2A	A)		tfi		_	0.17	0.35	

(1) Pulse Test : PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.







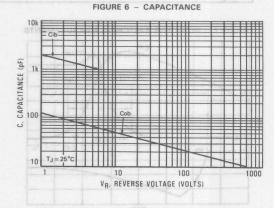
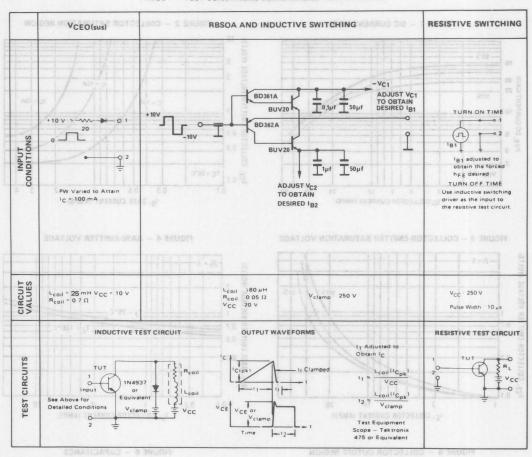
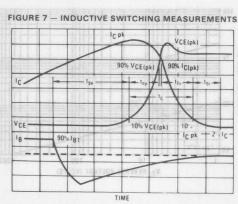
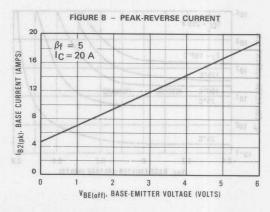


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE







#### MOLTAMACHMI ASAA OMITAASAO SAASWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% IB1 to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90 - 10% IC

tti = Current Tail, 10-2% IC

t<sub>c</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv}+t_{fi}\simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{o}\mathrm{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $(t_{\text{C}}$  and  $t_{\text{SV}})$  which are guaranteed at  $100^{o}\mathrm{C}$ .

#### INDUCTIVE SWITCHING

FIGURE 9 - STORAGE TIME, Tsv

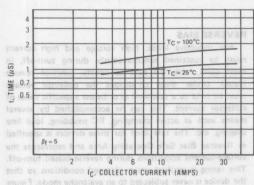


FIGURE 10 - CROSSOVER AND FALL TIMES

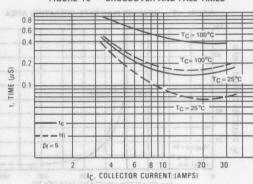


FIGURE 11a - TURN-OFF TIMES vs FORCED GAIN

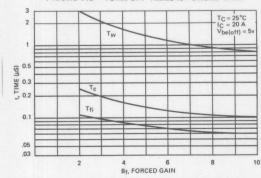
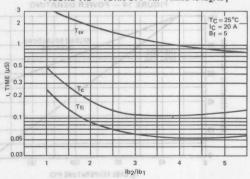
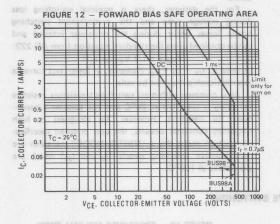
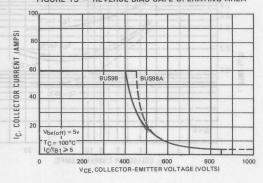


FIGURE 11b - TURN-OFF TM TIMES vs lb2/lb1

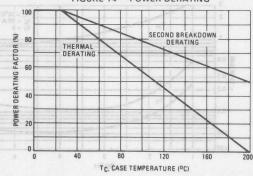








#### FIGURE 14 - POWER DERATING



#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C = 25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J(pk)</sub> may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

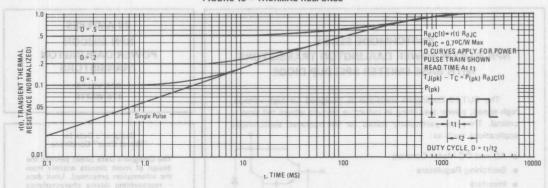
#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.

3

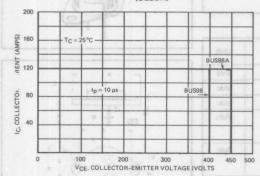
M MOTOROLA

#### FIGURE 15 - THERMAL RESPONSE

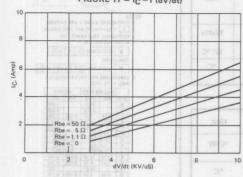


#### **OVERLOAD CHARACTERISTICS**

## FIGURE 16 – RATED OVERLOAD SAFE OPERATING AREA (OLSOA)



#### FIGURE 17 - IC = f (dV/dt)



#### OLSOA

OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known.

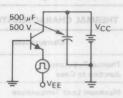
Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

#### FIGURE 18 - OVERLOAD SOA TEST CIRCUIT

#### Notes:

- V<sub>CE</sub> = V<sub>CC</sub> + V<sub>BE</sub>
- Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>





# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

- AC and DC Motor Controls
- Switching Regulators
- Inverters
- · Solenoid and Relay Drivers
- Fast Turn-Off Times  $\approx$  100 and Inductive Fall Time at 25°C (Typ) 1.1  $\mu$ S Inductive Storage Time at 25°C (Typ)
- Operating Temperature Range 65 to 200°C

# e-operated switchmode

IGURE 15 - THERMAL RESPONSE

## MAXIMUM RATINGS

ns energy fluctuating democra boog A.	Symbol	BUT13	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	400	Vdc
Collector-Emitter Voltage	VCEV	600	Vdc
Emitter Base Voltage	VEB	nwonx 10	Vdc
Collector Current - Continuous - Peak(1)	I <sub>C</sub>	28 35	Adc
Base Current Aviso of crini be of Continuous  — Peak (1)	bridgeget	ov sud 6	Adc
Free Wheel Diode : Forward current — Continuous — Peak	I <sub>F</sub>	28 28 35	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above 25°C	PD	175 100	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, June 110.  Junction to Case	ROJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purpose: 1/8" from Case for 5 Seconds	ΤL	275	°C

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%

#### 28 AMPERES

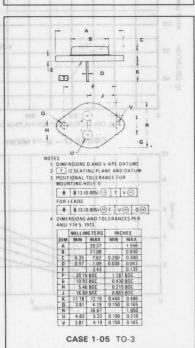
# NPN SILICON POWER DARLINGTON TRANSISTORS

600 VOLTS

#### Designer's Data for "Worst Case" Conditions

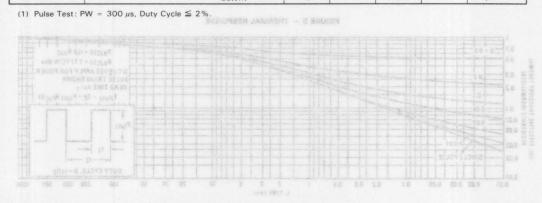
The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data – representing device characteristics boundaries – are given to facilitate "worst case" design.

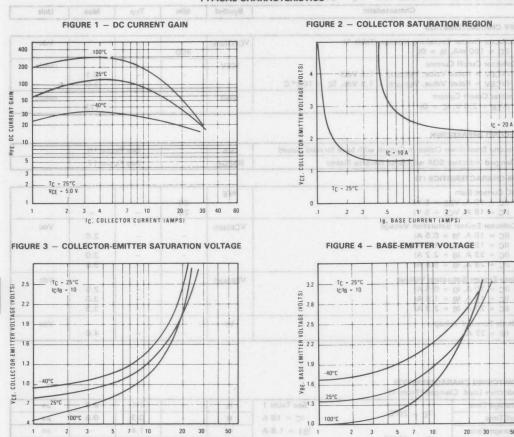


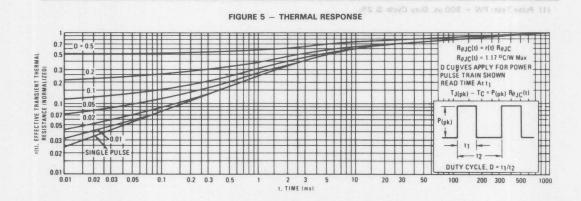


#### ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTERISTICS			PRAD T	NO CURREN	J - 1 39U0	R	
Collector-Emitter Sustaining Voltage (Table 1) (IC = 100 mA, IB = 0)		VCEO(sus)	400	HHI	F001	Vdc	100
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc) (VCEV = Rated Value, VBE(off) = 1.5 Vdc, TC = 1	100°C	ICEV			0.1	mAdc	00
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	MIJOR	IEBO	1/2		175	mAdc	9
SECOND BREAKDOWN	DMITTER THE THE THE THE THE THE THE THE THE THE						
Second Breakdown Collector Current with base forward	rd biased	IS/b		See Fi	gure 16		П
Clamped Inductive SOA with Base Reverse Biased	18	RBSOA		See Fi	gure 17		2
ON CHARACTERISTICS (1)	20					55 × 57	10 00
DC Current Gain (IC = 10 A, VCE = 5 V) (IC = 18 A, VCE = 5 V)		hFE	30 20	01 _ 1	3 _ 6	VOE - 2	1
Collector-Emitter Saturation Voltage (IC = 10 A, IB = 0.5 A) (IC = 18 A, IB = 1.8 A) (IC = 22 A, IB = 2.2 A) (IC = 28 A, IB = 5.6 A)		VCE(sat)	MORABUI	AS SETTION	2.0 2.5 3.0 5.0	Vdc	BU
Base-Emitter Saturation Voltage (IC = 10 A, IB = 0.5 A) (IC = 18 A, IB = 1.8 A) (IC = 22 A, IB = 2.2 A)	14 pt 15 st	VBE(sat)	1/2/	=	2.5 3.0 3.3	Vdc	74 LA
Diode Forward Voltage (IF = 22 A)	ABILIA	Vf	1		4.0	Vdc	100
SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)	STEWN AND AND AND AND AND AND AND AND AND AN		1	1/4		2704	0 0
	See Table 1	ts	-	1.1	2.6	μs	
Fall Time TC = 25°C	IC = 18 A	tf	-	0.3	0.8	μs	
	IB1 = 1.8 A	ts	St #6	1.4	8 -6	μs	
Fall Time TC = 100°C	BE(off) = 5 V	tf	DYNA	0.33	14103 20	μs	

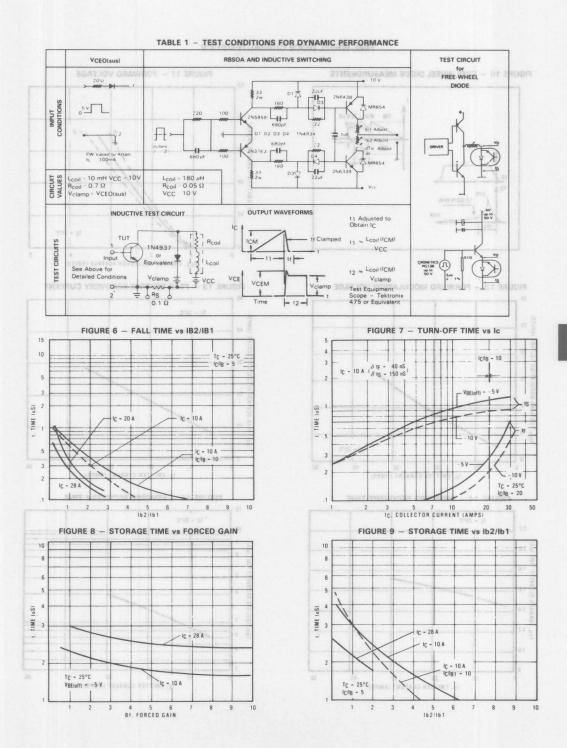






IC. COLLECTOR CURRENT (AMPS)

IC. COLLECTOR CURRENT (AMPS)



# FREE-WHEEL DIODE CHARACTERISTICS

FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

TEST CISCUIT

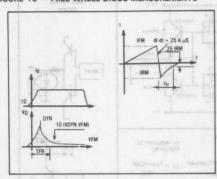


FIGURE 11 - FORWARD VOLTAGE

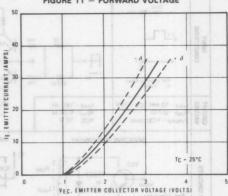


FIGURE 12 - FORWARD MODULATION VOLTAGE

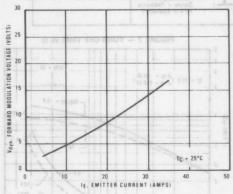


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

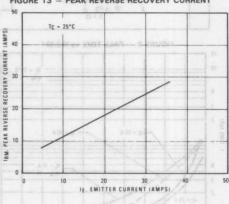


FIGURE 14 - FORWARD RECOVERY TIME

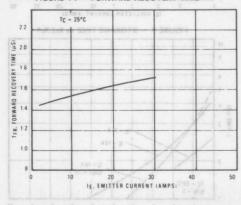
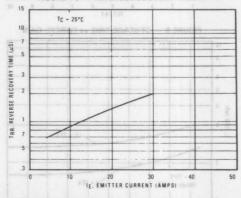


FIGURE 15 - REVERSE RECOVERY TIME



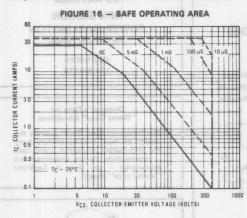
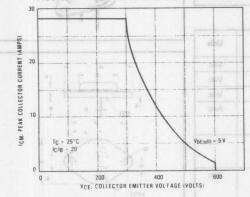


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

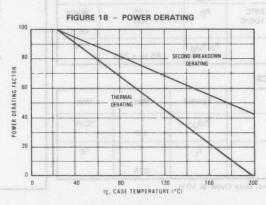
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

The data of Figure 16 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

 $T_{J(pk)}$  may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.



# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

MOITAMOONI AREA BRITARING STAR

The BUT14 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- bour Inverters' sough no awarie sagariov edit ta toes
- Solenoid and Relay Drivers
- Fast Turn-Off Times

  300 nS Inductive Fall Time at 25°C (Typ)

  1.3 µS Inductive Storage Time at 25°C (Typ)
- Operating Temperature Range 65 to 200°C

# 25 AMPERES NPN SILICON

POWER DARLINGTON
TRANSISTORS

850 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries – are given to facilitate "worst case" design.



#### MAXIMUM RATINGS

teom ni , to-mRating ath ylauoeneth	Symbol	BUT14	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	1 500	Vdc
Collector-Emitter Voltage	VCEV	68 8 01 850	Vdc
Emitter Base Voltage	V <sub>EB</sub>	10 10	Vdc
Collector Current  - Continuous  - Peak (1)	IC.	25	Adc
Base Current - Continuous - Peak (1)	10	5 7.5	Adc
Free Wheel Diode: Forward current - Continuous - Peak	I <sub>F</sub>	25 35	Adc
Total Power Dissipation @T <sub>C</sub> = 25°C @T <sub>C</sub> = 100°C Derate above 25°C	PD 0	175 100	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ROJC	1.0	°C/W
Maximum' Lead Temperature for Soldering Purpose:	TL		°C
1/8" from Case for 5 Seconds		275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.



- 2 T IS SEATING PLANE AND DATUM
  3 POSITIONAL TOLERANCE FOR
  MOUNTING HOLE 0
- ♦ 13 (0 005) ⊙ T V ⊗
- FOR LEADS

  | ♦ | ♦ 13 (0.005) ⊙ T | V ⊙ | 0 ⊙
- 4 DIMENSIONS AND TOLERANCES PER ANSI V14 5, 1973

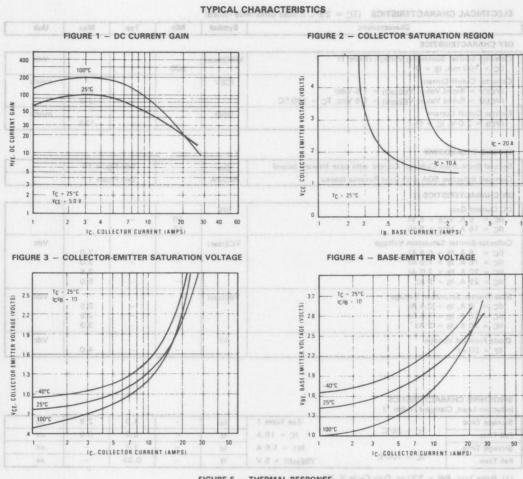
	MILLIN	METERS	INC	HES	
MIG	MIN	MAX	MIN	MAX	
Α		39.37		1 550	
8	20	21.08		0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E		3 43		0.135	
F	30 15	BSC	1.187 BSC		
G	10.92	BSC	0 430 BSC		
H	5.48	BSC	0.215 BSC		
J	16.89	BSC	0.665	BSC	
K	11.18	12 19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R		26 67		1.050	
U	4.83	5 3 3	0 190	0.210	
V	3.81	4 19	0 150	0 165	

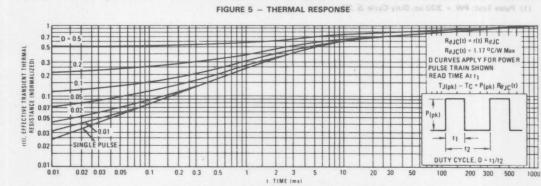
CASE 1-05 TO-3

#### ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	a anoser		PROPERTY OF STREET	Municipal Con	T INUDE	
Collector-Emitter Sustaining Voltage (Table (IC = 100 mA, IB = 0)	1)	VCEO(sus)	500	-	Han	Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 V (VCEV = Rated Value, VBE(off) = 1.5 V		ICEV			0.2	mAdc
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	- 4 8	IEBO	1/		175	mAdc
SECOND BREAKDOWN	96 591		1			01
Second Breakdown Collector Current with I	base forward biased	IS/b		See Fig	gure 16	
Clamped Inductive SOA with Base Reverse	Biased	RBSOA		See Fig	gure 17	
ON CHARACTERISTICS (1)	1 - 01			111111	2-6	2 10
DC Current Gain (IC = 8 A, VCE = 5 V) (IC = 16 A, VCE = 5 V)		hFE 1	30 15	DI TI	1 7 1	1
Collector-Emitter Saturation Voltage (IC = 8 A, IB = 0.4 A) (IC = 16 A, IB = 1.6 A) (IC = 20 A, IB = 2.0 A) (IC = 25 A, IB = 5 A)	NUSSEE	VCE(sat)	OTT <u>Q</u> RUTA	e narýtusa:	2.0 3.0 3.5 5.0	Vdc 0 - 8 ARUOI
Base-Emitter Saturation Voltage (IC = 8 A, IB = 0.4 A) (IC = 16 A, IB = 1.6 A) (IC = 20 A, IB = 2 A)	13 — 5x 15 — 5x	VBE(sat)	1	-	2.5 2.9 3.3	Vdc
Diode Forward Voltage (IF = 20 A)	41 51 62	Vf	1/		4.0	Vdc
SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)	710 (1) 200 200 (1) 200 200 (1) 200			1		395- g) 3751
Storage Time	See Table 1	ts	- 1	1.3	2.8	μs
Fall Time TC = 25°C	IC = 16 A	tf		0.3	0.8	μs
Storage Time	IB1 = 1.6 A	ts	(S)	1.5	-	μs
Fall Time TC = 100°C	VBE(off) = 5 V	tf		0.35	_	μs

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2% γου επι μανηθήτ — ε επίση απουργαθή με το επίση απουργαθή με το επίση απουργαθή επίση επίση





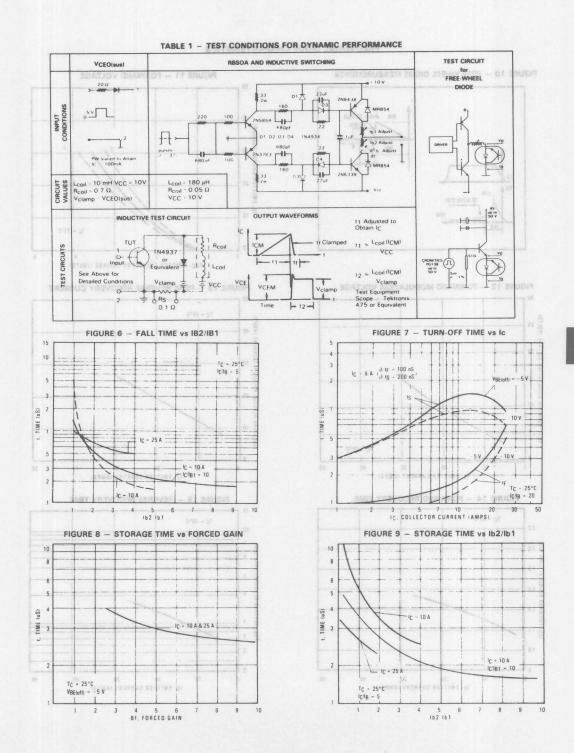


FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

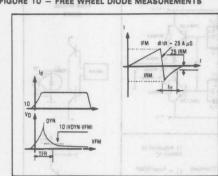


FIGURE 11 - FORWARD VOLTAGE

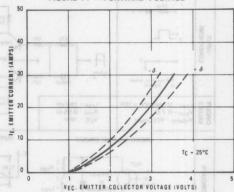


FIGURE 12 - FORWARD MODULATION VOLTAGE

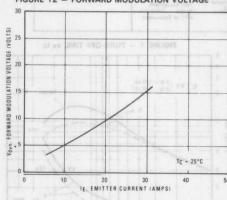


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

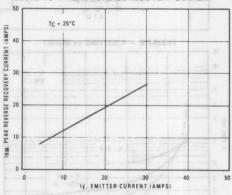


FIGURE 14 - FORWARD RECOVERY TIME

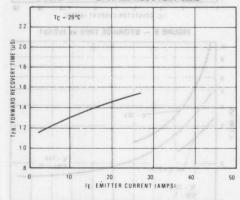
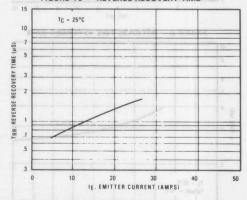


FIGURE 15 - REVERSE RECOVERY TIME



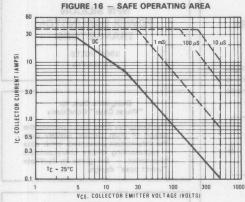
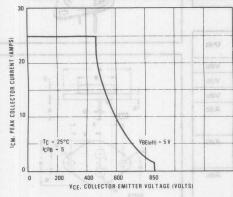


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



# FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

The data of Figure 16 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

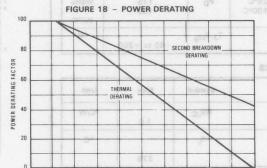
T<sub>J(pk)</sub> may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased.

Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

160 Nov 2 vt. 200 am d = Night salus JasT oslus (1



80 120 IC. CASE TEMPERATURE (°C)

40



The BUT 15 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as: I newood no probneds bideliev

- AC and DC Motor Controls
- Switching Regulators
- brue Inverters anupil no mode espation and to tru
- Solenoid and Relay Drivers
- Fast Turn-Off Times
  300 nS Inductive Fall Time at 25°C (Typ) 1.2 µS Inductive Storage Time at 25°C (Typ)
- Operating Temperature Range 65 to 200°C

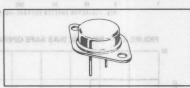
# 20 AMPERES **NPN SILICON**

**POWER DARLINGTON TRANSISTORS** 

> 1000 VOLTS 175 WATTS

# Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries – are given to facilitate "worst case" design.



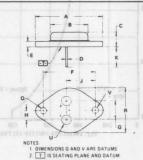
## **MAXIMUM RATINGS**

taon of the Rating had held mant must	Symbol	BUT15	Unit
Collector-Emitter Voltage	VCEO(sus)	traba( 700	Vdc
Collector-Emitter Voltage	VCEV	162 8 01000	Vdc
Emitter Base Voltage	VEB	-100m2 10	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub>	163 BHT 20 22 26 25	Adc
Base Current  — Continuous  — Peak(1)	N SI NO	BILL TIO 5	Adc
Free Wheel Diode: Forward current - Continuous - Peak	I <sub>F</sub>	20 25	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above 25°C	PD	175 100 100 - 1	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Case		ROJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purpose:		TL		°C
1/8" from Case for 5 Seconds	12		275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.



T IS SEATING PLANE AND DATUM
POSITIONAL TOLERANCE FOR
MOUNTING HOLE 0

♦ • 13 (0.005) · T V ·

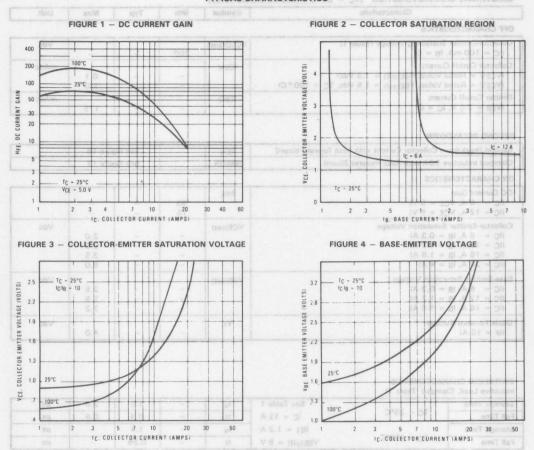
♦ • 13 (0.005) ⊕ T V ⊕ 0 ⊕ DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

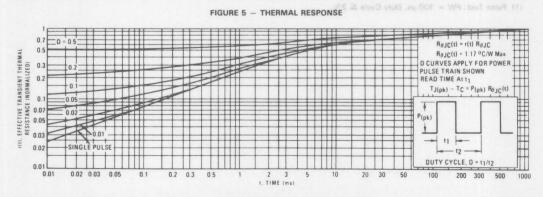
CASE 1-05 TO-3

# ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted

Characteristic	Characteristic			Тур	Max	Unit
OFF CHARACTERISTICS	S. BALLDER	The same	MAD TH	DC CUMBE	- f BRUDR	
Collector-Emitter Sustaining Voltage (Table (IC = 100 mA, IB = 0)	1)	VCEO(sus)	700			Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 \( (VCEV = Rated Value, VBE(off) = 1.5 \)	ICEV	-	1	0.1	mAdc	
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	IEBO			175	mAdc	
SECOND BREAKDOWN						
Second Breakdown Collector Current with	base forward biased	IS/b		See Fi	gure 16	
Clamped Inductive SOA with Base Reverse	Biased	RBSOA		See Fi	gure 17	- T
ON CHARACTERISTICS (1)	l b				20-25 -	57
DC Current Gain (IC = 6 A, VCE = 5 V)	0	hFE	30	ЩШ	V 9.67	1
(IC = 12 A, VCE = 5 V)		00 00 0	15	01		
Collector-Emitter Saturation Voltage (IC = 6 A, IB = 0.3 A) (IC = 12 A, IB = 1.2 A) (IC = 16 A, IB = 1.6 A)		VCE(sat)	ATURASTION	E 63 TO 1613	2.0 3.0 3.5	Vdc = 8. BRUDI
(IC = 20 A, IB = 4 A)		HIII	-	-	5.0	
	9.5 <sup>1</sup> - 5.5 (2)	VBE(sat)	1=/	=	2.5 2.9 3.3	Vdc 2g
Diode Forward Voltage (IF = 16 A)	- 10 A	Vf	1-1		4.0	Vdc
				M		51
SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)	11 m m					12 795
Storage Time	See Table 1	ts		1.2	2.5	μs
Fall Time TC = 25°C	IC = 12 A	tf		0.3	0.8	μs
Storage Time	IB1 = 1.2 A	ts	05_	1.4	4	μs
Fall Time	VBE(off) = 5 V	tf	12/19/61	0.35	1007.31	μs

(1) Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.





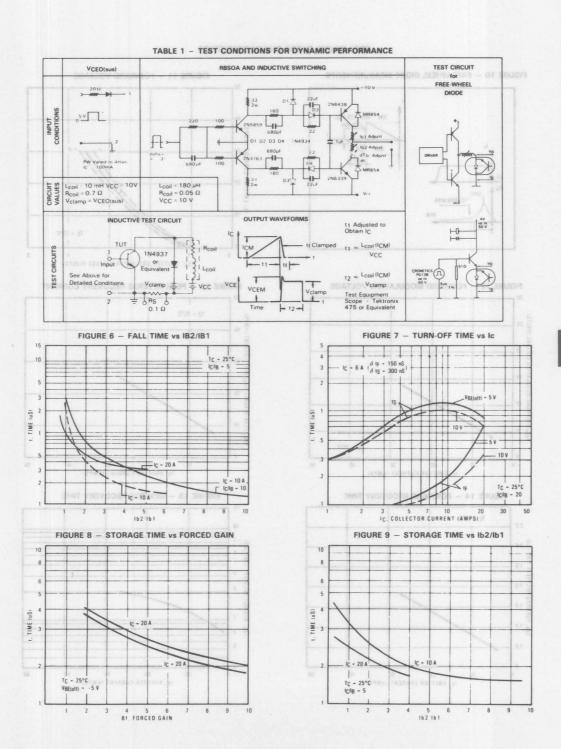


FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

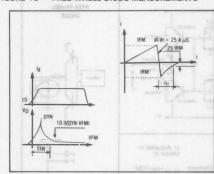


FIGURE 11 - FORWARD VOLTAGE

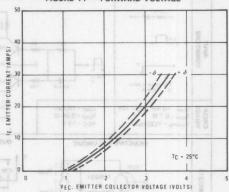


FIGURE 12 - FORWARD MODULATION VOLTAGE

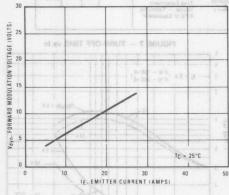


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

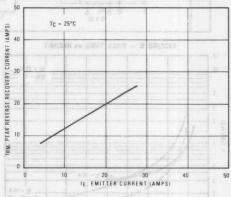


FIGURE 14 - FORWARD RECOVERY TIME

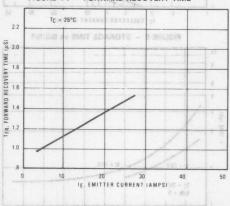


FIGURE 15 - REVERSE RECOVERY TIME

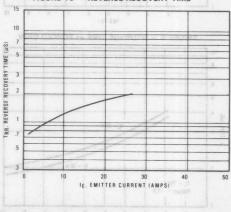


FIGURE 16 - SAFE OPERATING AREA

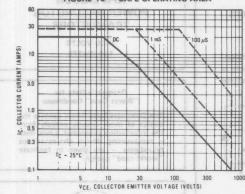
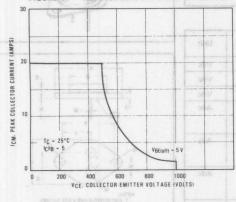


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



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# SAFE OPERATING AREA INFORMATION

## FORWARD BIAS

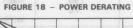
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

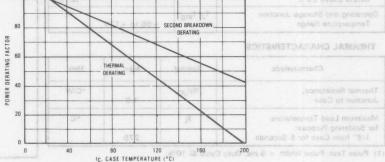
The data of Figure 16 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

 $T_{J(pk)}$  may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turnoff. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.







The BUT 16 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as: nawno no gnibnegab oldensy

Figure 18.

- AC and DC Motor Controls
- Switching Regulators
   O
- bru . Inverters' stugill no nworte aspertov and to the
- Solenoid and Relay Drivers
  - Fast Turn-Off Times

2.0 uS Inductive Fall Time at 100°C (Typ) 0.8 uS Inductive Storage Time at 100°C (Typ)

Operating Temperature Range - 65 to 175°C



# 12 AMPERES

# NPN SILICON **POWER DARLINGTON** TRANSISTORS

**1400 VOLTS** 150 WATTS

# Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries - are given to facilitate "worst case" design.



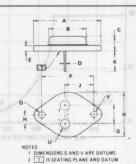
# **MAXIMUM RATINGS**

team memuo dpid bite agettov dpid abiteom di ho-m Rating per yleuce estlu	Symbol	BUT16	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	1000	Vdc
Collector-Emitter Voltage and a world as	VCEV	se a of 1400	Vdc
Emitter Base Voltage	VEB	10	Vdc
Collector Current - Continuous - Peak (1)	1 10	12 20	Adc
Base Current  - Continuous  - Peak (1)	IBM	dT to 8	Adc
Free Wheel Diode : Forward current - Continuous - Peak	I <sub>F</sub>	12 20	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	150 75	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 to +175	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ROJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purpose:	TL		°C
1/8" from Case for 5 Seconds		275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.



- T IS SEATING PLANE AND DATUM
  POSITIONAL TOLERANCE FOR
  MOUNTING HOLE O
- ♦ 13 (0.005) · T V ·
- FOR LEADS ♦ • 13 (0.005) · T V · Q · Q ·
- DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

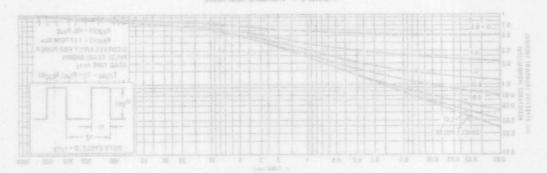


CASE 1-05 TO-3

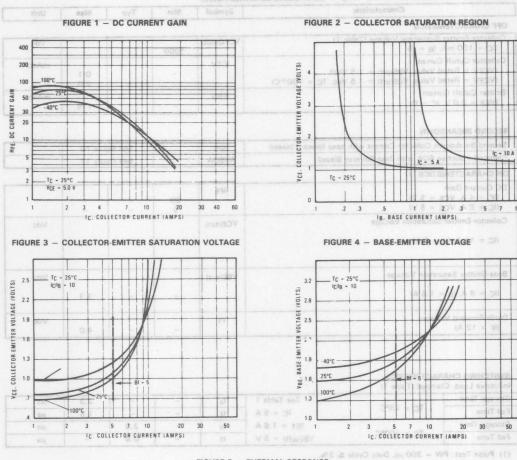
# ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit	
OFF CHARACTERISTICS	ROURE		PHAD THE	RAUD DU	- Lambara	
Collector-Emitter Sustaining Voltage (Table (IC = 100 mA, IB = 0)	1)	VCEO(sus)	1000	HIII	77	Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 V (VCEV = Rated Value, VBE(off) = 1.5 V	ICEV	-	1	0.1	mAdc	
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	IEBO		H	175	mAdc	
SECOND BREAKDOWN				A		05
Second Breakdown Collector Current with b	IS/b	201	See Fi	gure 16		
Clamped Inductive SOA with Base Reverse	RBSOA	- 19/	See Fi	gure 17		
ON CHARACTERISTICS (1)						27 25
DC Current Gain (IC = 4 A, VCE = 5 V) (IC = 8 A, VCE = 5 V)		hFE	20		1 1 5	- 304
Collector-Emitter Saturation Voltage (IC = 12 A, IB = 6 A)		VCE(sat)	ACITA-RUTA	na prikas	0075.0 l00	Vdc — £ 3AU£
Base-Emitter Saturation Voltage	- 37	VBE(sat)				Vdc
(IC = 8 A, IB = 1.6 A)	82 g		-		3.3	55
Diode Forward Voltage (IF = 12 A)	Sample St.	Vf	-	N	4.0	Vdc
SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)	- 701 - 51 m					
Storage Time	See Table 1	ts	- 1		3.3	μs
Fall Time TC = 25°C	IC = 8 A	tf	- 1		1.5	μs
Storage Time	IB1 = 1.6 A	ts	05-	2.0	4 1	μs
Fall Time	VBE(off) = 5 V	tf	12,414,517,14	0.8	100 21	μs

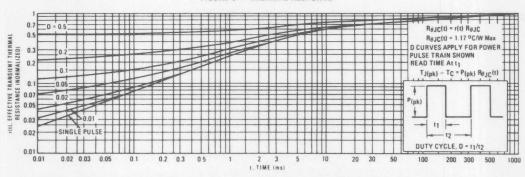
(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%.



## TYPICAL CHARACTERISTICS OT CONTRIBUTOARAMO JACIRTOLIS









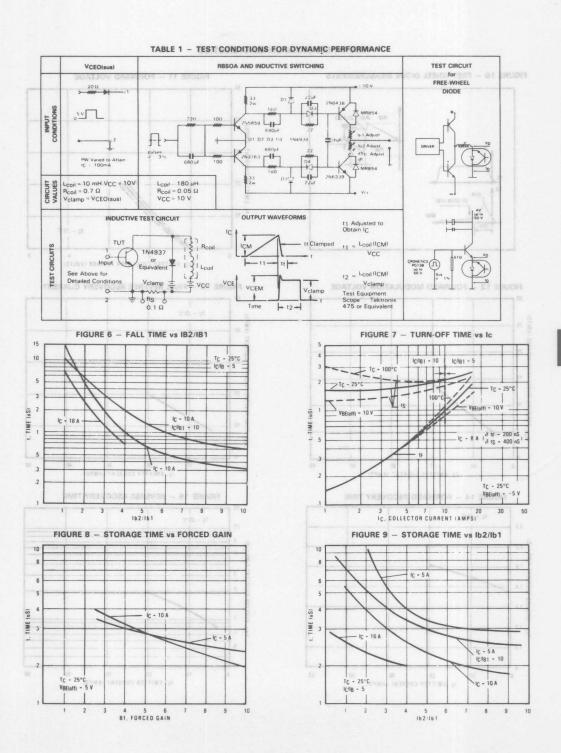


FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

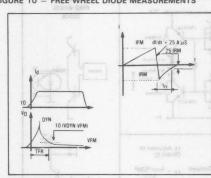


FIGURE 11 - FORWARD VOLTAGE

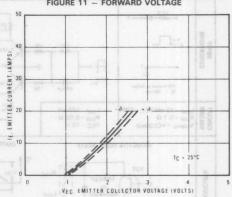


FIGURE 12 - FORWARD MODULATION VOLTAGE

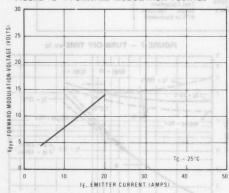


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

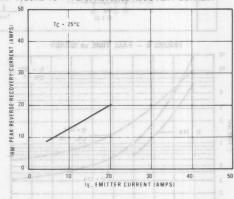


FIGURE 14 - FORWARD RECOVERY TIME

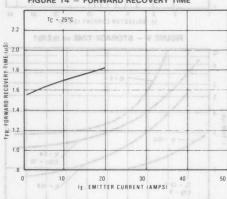
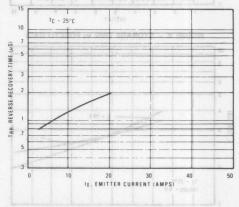


FIGURE 15 - REVERSE RECOVERY TIME



The Safe Operating Area figures shown in Figures 16 and 17 are specified for these devices under the test conditions shown.

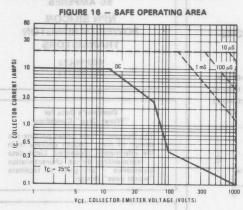
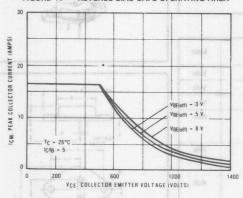


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



## SAFE OPERATING AREA INFORMATION

## FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

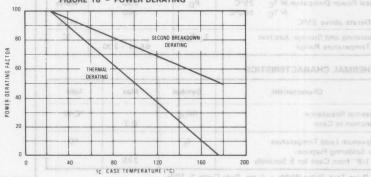
The data of Figure 16 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

 $T_{J(pk)}$  may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

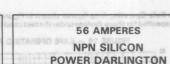






The BUT33 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
  - Solenoid and Relay Drivers
- Fast Turn Off Times
   800 nS Inductive Fall Time at 25°C (Typ)
   2.0 µS Inductive Storage Time at 25°C (Typ)
  - Operating Temperature Range 65 to 200°C



600 VOLTS 250 WATTS

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.

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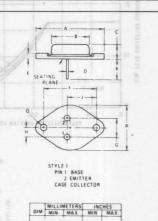
# MAXIMUM RATINGS

Rating beseid serever not out terms of see	Symbol	BUT33	Unit
Collector Emitter Voltage	VCEO(sus)	400	Vdc
Collector Emitter Voltage	VCEV	600	Vdc
Emitter Base Voltage			Vdc
Collector Current Continuous Peak (1)	TO ICM	2 asi8 56	Adc
Base Current Continuous Peak(1) 20121919191919 AO228 9	IR IR	dy facts 12	Adc
Free Wheel Diode . Forward current Continuous Peak	l <sub>F</sub>	56 75	Adc III
Total Power Dissipation (@ T <sub>C</sub> = 25°C (@ T <sub>C</sub> = 100°C Derate above 25°C	PD	250 140	Watts W. °C
Operating and Storage Junction Temperature Range	TJ. Tstg	65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance. Junction to Case	ROJC	0.7	°C,W
Maximum Lead Temperature for Soldering Purpose:	Τι		°C
1/8" from Case for 5 Seconds	197 9	275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.

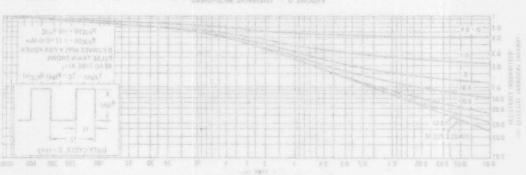


	MILLI	MILLIMETERS		MES
DIM	MIN	MAX	MIN	MAX
A		39 37		1 550
8		21 08		0 830
C	6 35	7 62	0 250	0.300
D	0 99	1 09	0 039	0 043
E		3 43		0 135
F	29 90	30 40	1 177	1 197
G	10 67	11 18	0 420	0 440
Н	5 33	5 59	0 210	0 220
J	16 64	17 15	0 655	0 675
K	11 18	12 19	0 440	0 480
0	3 84	4 09	0 151	0 161
R		26 F?		1 050

CASE 197-01 MODIFIED TO-3

Storage Time			IC = 36 A	ts	-	2.0	3.3	μs
Fall Time	TC = 25°C	See Table 1	IB = 3.6 A	tf		0.8	1.6	μs
Storage Time				ts	DE US	2.2	-5	μs
Fall Time	TC = 100°C		VBE(off) = 5 V	tf		0.8	-	μs

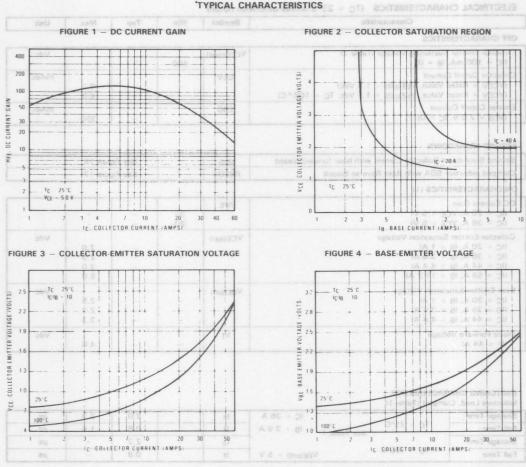
(1) Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2% MARSHY = 8 3RLORS

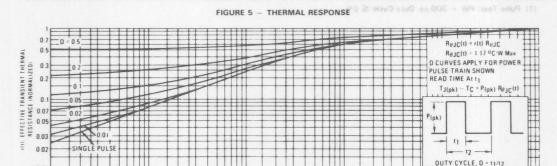


200 300 500

1000

100





0 02 0 03 0 05 0 1

0.2 0.3 0.5

0.01

3

1 TIME Imsi

10

20 30 50



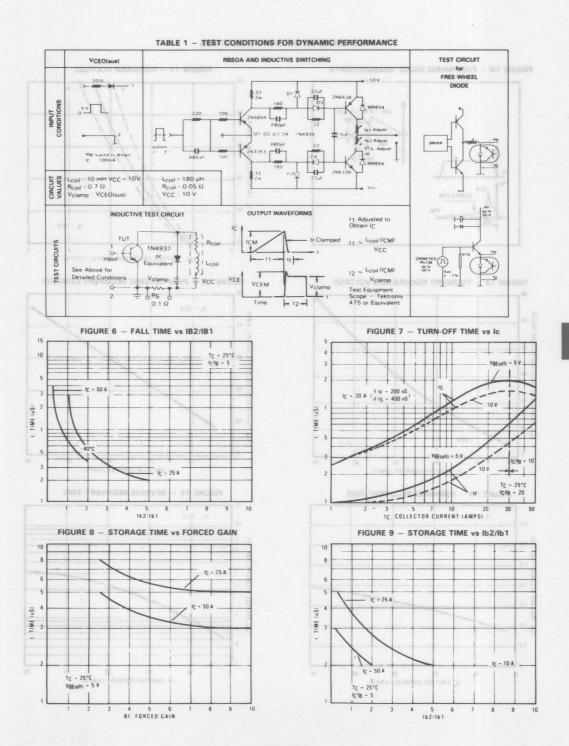


FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

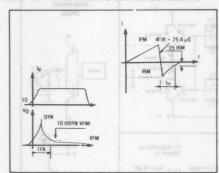


FIGURE 11 - FORWARD VOLTAGE

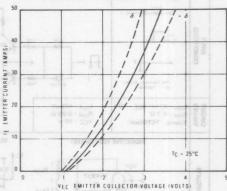


FIGURE 12 - FORWARD MODULATION VOLTAGE

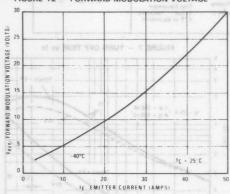


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

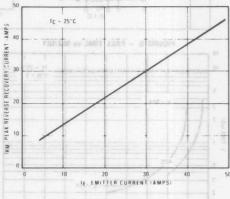


FIGURE 14 - FORWARD RECOVERY TIME

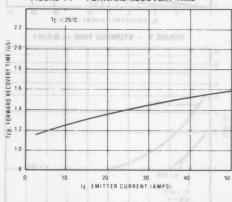
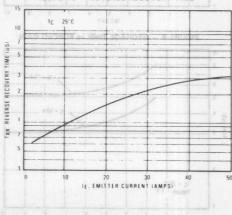
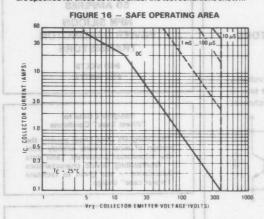


FIGURE 15 - REVERSE RECOVERY TIME





The Safe Operating Area figures shown in Figures 16 and 17 are specifed for these devices under the test conditions shown.



LECTOR 1100 PEAK TC - 25"C

CASE 197-01

FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA

# SAFE OPERATING AREA INFORMATION

# FORWARD BIAS

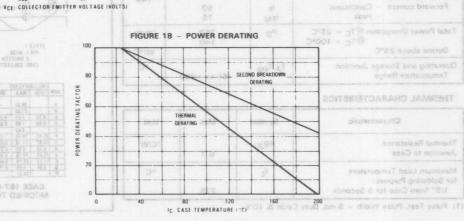
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCF limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

The data of Figure 16 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

TJ(pk) may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# REVERSE BIAS

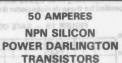
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage current condition allowable during reverse biased turnoff. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.





The BUT34 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

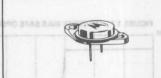
- AC and DC Motor Controls
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Fast Turn-Off Times
- 0.7 uS Inductive Fall Time at 25°C (Typ) \*50 1.8 uS Inductive Storage Time at 25°C (Typ)
  - Operating Temperature Range 65 to 200°C



850 VOLTS 250 WATTS

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data – representing device characteristics boundaries – are given to facilitate "worst case" design.



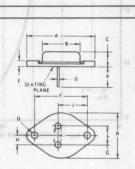
## MAXIMUM RATINGS

taom ni ,lle-n Rating ub ylaboenatlu			Unit
Collector-Emitter Voltage			Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage	VEB	10	Vdc
Collector Current - Continuous - Peak (1)	IC I	50 75	Adc
Base Current  - Continuous  - Peak (1)	ai priita i	10 15	Adc
Free Wheel Diode: Forward current Continuous Peak	l <sub>F</sub>	50 75	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	250 140	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	0.7	°C/W
Maximum Lead Temperature	T <sub>L</sub>		°C
for Soldering Purpose: 1/8" from Case for 5 Seconds		275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.



PIN 1. BASE 2 EMITTER CASE COLLECTI

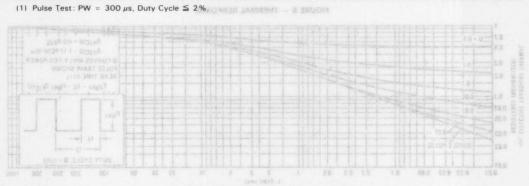
- 50	MILLI	MILLIMETERS		HES
DIM	MIN	MAX	MIN	MAX
A		39.37	-	1 550
8	-	21.08		0.830
C	6.35	7 62	0.250	0.300
D	0.99	1 09	0.039	0.043
E	-	3.43		0.135
F	29 90	30.40	1 177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
1	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0 480
0	3.84	4.09	0.151	0.161
A		26.67		1 050

CASE 197-01 MODIFIED TO-3

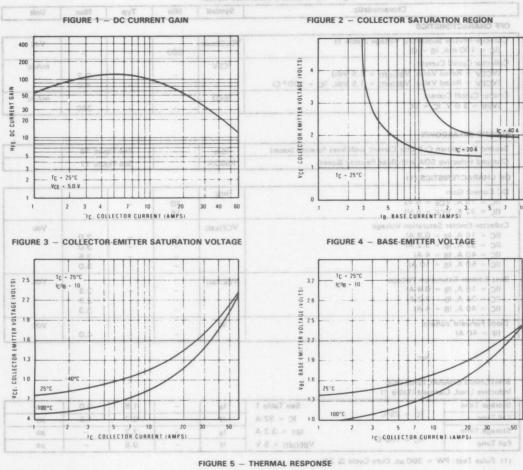
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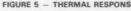
# ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

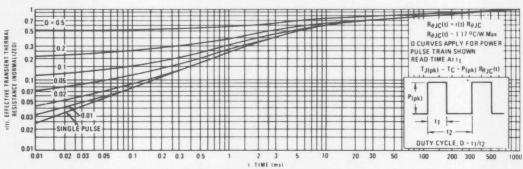
Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	IUDIN.		BURE STO	INIOS OU	T GROWT	
Collector-Emitter Sustaining Voltage (Table 1) (IC = 100 mA, IB = 0)		VCEO(sus)	500			Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc) (VCEV = Rated Value, VBE(off) = 1.5 Vdc,	TC = 100°C)	ICEV	-		0.2	mAdc
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	S ADITI	IEBO			350	mAdc
SECOND BREAKDOWN	or Switt	K				05
Second Breakdown Collector Current with base	forward biased	IS/b		See Fi	gure 16	
Clamped Inductive SOA with Base Reverse Bias	sed	RBSOA		See Fi	gure 17	
ON CHARACTERISTICS (1)	9	11.4-4-			3-85	2 10 -
DC Current Gain (IC = 16 A, VCE = 5 V) (IC = 32 A, VCE = 5 V)	10	hFE /	30 15	01 7 01 7 0203 70131	# T \$	
Collector-Emitter Saturation Voltage (IC = 16 A, IB = 0.8 A) (IC = 32 A, IB = 3.2 A) (IC = 40 A, IB = 4 A) (IC = 50 A, IB = 10 A)		VCE(sat)	OTTABUTA	е явт <u>ў</u> ша-	2.0 3.0 3.5 5.0	Vdc - £ BRUDH
Base-Emitter Saturation Voltage (IC = 16 A, IB = 0.8 A) (IC = 32 A, IB = 3.2 A) (IC = 40 A, IB = 4 A)	5.5 - 8.5 - 8.5 - 8.5	VBE(sat)	-	-	2.5 2.9 3.3	Vdc
Diode Forward Voltage (IF = 40 A)	185 5	Vf	-		4.0	Vdc
40°C SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)	27 E				2193	295
Storage Time	See Table 1	ts	-	1.8	3.0	μs
Fall Time TC = 25°C	IC = 32 A	tf		0.7	1.5	μs
Storage Time	IB1 = 3.2 A	ts	(2.987) 19	2.2	100 10	μs
Fall Time TC = 100°C	VBE(off) = 5 V	tf	-	0.8	-	μs



# TYPICAL CHARACTERISTICS TO SOLITORIAN JACKTORIES









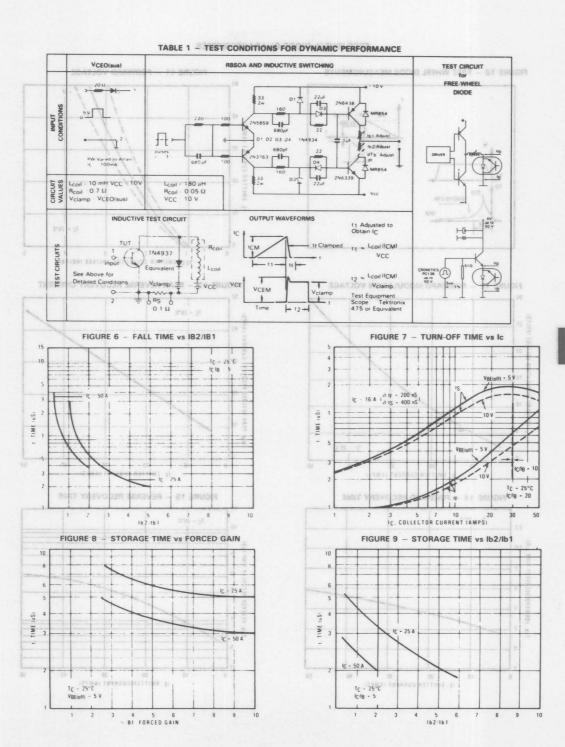


FIGURE 10 - FREE WHEEL DIODE MEASUREMENTS

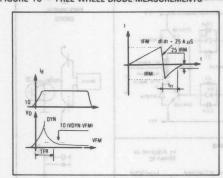


FIGURE 11 - FORWARD VOLTAGE

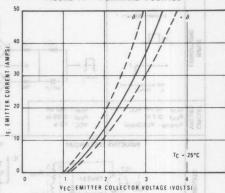


FIGURE 12 - FORWARD MODULATION VOLTAGE

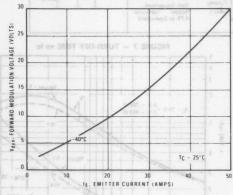


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT

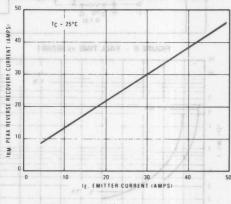


FIGURE 14 - FORWARD RECOVERY TIME

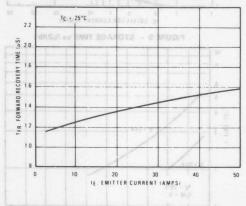
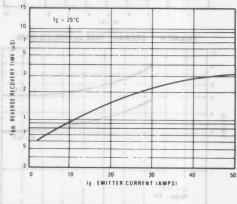
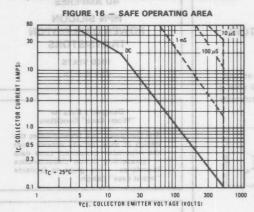


FIGURE 15 - REVERSE RECOVERY TIME

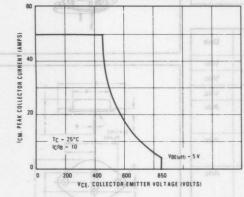




The Safe Operating Area figures shown in Figures 16 and 17 are specifed for these devices under the test conditions shown.



## FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



# SAFE OPERATING AREA INFORMATION

# FORWARD BIAS

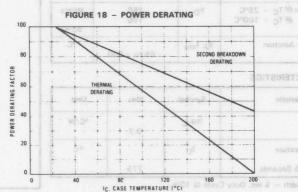
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

The data of Figure 16 is based on T<sub>C</sub> = 25°C; T<sub>J</sub>(p<sub>k</sub>) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

 $T_{J(pk)}$  may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.





BAFE OFERALING AREA IMPORMATION

limits of the translator that must be observed for reliable

The BUT35 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators as small state of
- brue Inverters mugit no myorks appation and to triss
  - Solenoid and Relay Drivers
- Fast Turn-Off Times

  550 nS Inductive Fall Time at 25°C (Typ)

  2.5 uS Inductive Storage Time at 25°C (Typ)
  - Operating Temperature Range 65 to 200°C

# 40 AMPERES NPN SILICON POWER DARLINGTON

1000 VOLTS 250 WATTS

## Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries – are given to facilitate "worst case" design.

# SAFE OF ATIMO AREA REVERSE BLAS REVERSE BLAS RANTAR MUMIXAM

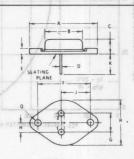
eds, high voltage and high current must nultaneously dugnits num-off, in most	Symbol	ua ad BUT35	Unit
Collector-Emitter Voltage	-		Vdc
Collector Emitter Voltage	VCEV	8 5 2 1000	Vdc
Emitter Base Voltage	VEB	10	Vdc
Collector Current - Continuous - Peak (1)	of level sh	The set	Adc
Base Current - Continuous - Peak (1)	mainer al	7 380	Adc
Free Wheel Diode: Forward current Continuous Peak	l <sub>F</sub>	40 50	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	250 140	Watts W/°C
	T <sub>J</sub> , T <sub>stg</sub>	65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Case		ROJC	0.7	°C/W
Maximum Lead Temperature for Soldering Purpose: 1/8" from Case for 5 Seconds	/	τι	275	°C

<sup>(1)</sup> Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.





STYLE 1
PIN 1 BASE
2 EMITTER
CASE COLLECTOR

	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A		39 37	-	1 550
8	-	21 08		0 830
C	6.35	7 62	0.250	0.300
D	0 99	1 09	0 039	0 043
E		3 43		0.135
F	29 90	30 40	1 177	1 197
G	10 67	11 18	0 420	0 440
н	5 33	5 59	0 210	0 220
J	16 64	17 15	0 655	0 675
K	11 18	12 19	0 440	0 480
0	3 84	4 09	0 151	0 161
R		26 67		1 050

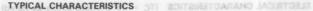
CASE 197-01 MODIFIED TO-3

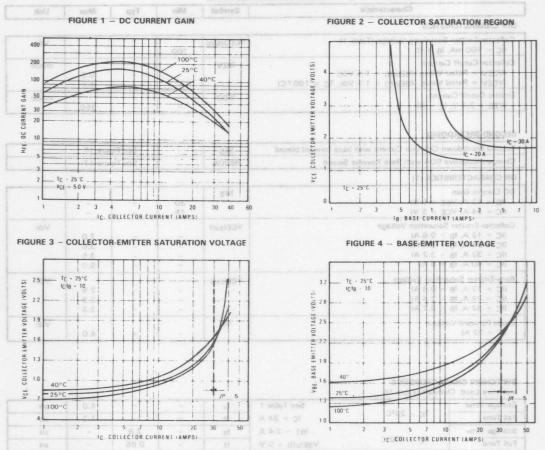
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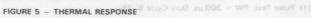
# ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

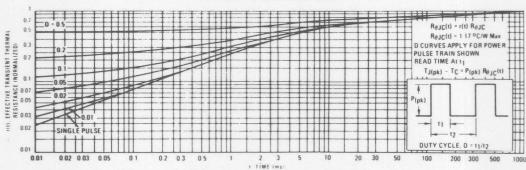
Characteristic	Symbol	Min	Тур	Max	Unit
DFF CHARACTERISTICS		MIND INS	(AUG 30 -	- Canada	
Collector-Emitter Sustaining Voltage (Table 1) (IC = 100 mA, IB = 0)	VCEO(sus)	700			Vdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc) (VCEV = Rated Value, VBE(off) = 1.5 Vdc, TC = 100 ° C)	ICEV			0.2	mAdc
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)	IEBO	7-		350	mAdc
SECOND BREAKDOWN	LA				01 E
Second Breakdown Collector Current with base forward biased	IS/b		See Fig	gure 16	= 3
Clamped Inductive SOA with Base Reverse Biased	RBSOA		See Fi	gure 17	
ON CHARACTERISTICS (1)	TILL			1.6	21 10
DC Current Gain (IC = 12 A, VCE = 5 V) (IC = 24 A, VCE = 5 V)	hFE	30 15	ALL.	1 - 1	
Collector Emitter Saturation Voltage (IC = 12 A, IB = 0.6 A) (IC = 24 A, IB = 2.4 A) (IC = 32 A, IB = 3.2 A) (IC = 40 A, IB = 8 A)	VCE(sat)	NOTTA NUTA	rstīma.	2.0 3.0 3.5 5.0	Vdc - £ 3RUĐA
Base-Emitter Saturation Voltage  (IC = 12 A, IB = 0.6 A)  (IC = 24 A, IB = 2.4 A)  (IC = 32 A, IB = 3.2 A)	VBE(sat)			2.5 2.9 3.3	Vdc 2
Diode Forward Voltage (IF = 32 A)	Vf	- 1		4.0	Vdc
SWITCHING CHARACTERISTICS Inductive Load, Clamped (Table 1)					21 8 3 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1
Storage Time See Table 1	ts	- 1		4.0	μs
Fall Time TC = 25°C IC = 24 A	tf	-		1.2	μs
Storage Time IB1 = 2.4 A	ts	190500-14-0	2.8	- 1	μs
Fall Time VBE(off) = 5 V	tf	-	0.65	-	μs

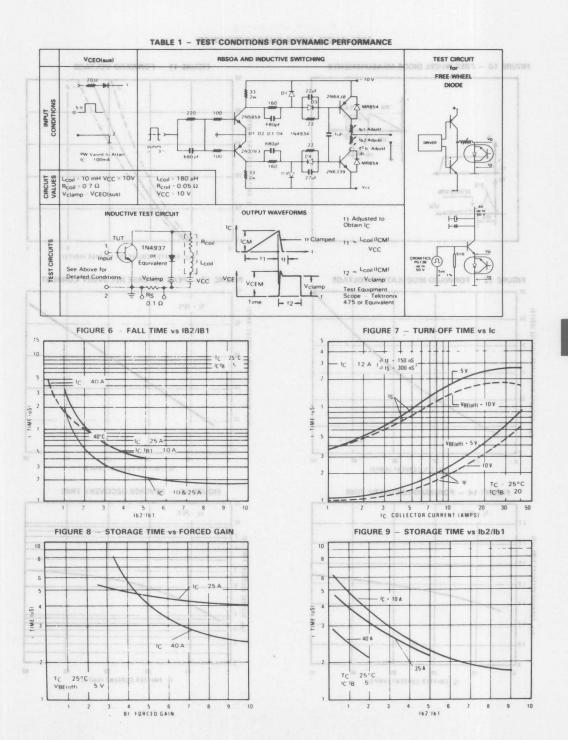
(1) Pulse Test: PW = 300 µs, Duty Cycle ≤ 2%.

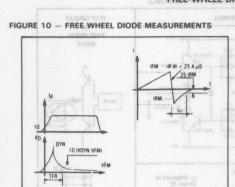


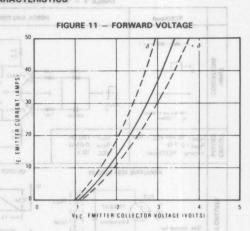




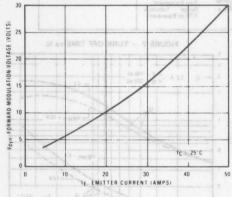




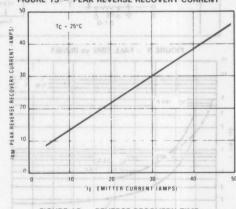












# FIGURE 14 - FORWARD RECOVERY TIME

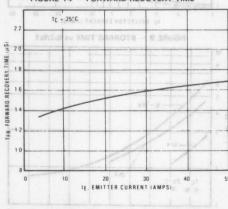
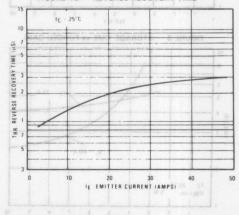


FIGURE 15 - REVERSE RECOVERY TIME



MAXIMUM RATINGS

The Safe Operating Area figures shown in Figures 16 and 17 are specifed for these devices under the test conditions shown.

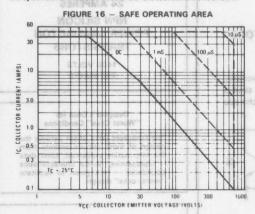
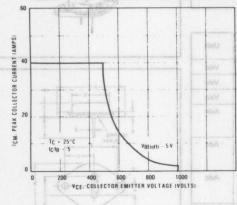


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA



CASE 197-01

# FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-Vcs limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

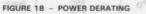
The data of Figure 16 is based on Tc = 25°C; Tl(nk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18.

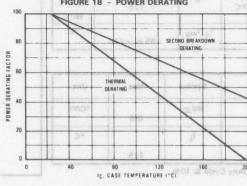
Tilink) may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltagecurrent condition allowable during reverse biased turnoff. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.

Characteristic

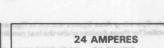






The BUT36 Darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
  - Solenoid and Relay Drivers
  - Fast Turn-Off Times
- 1.7 uS Inductive Fall Time at 100°C (Typ) \*50 4.5 uS Inductive Storage Time at 100°C (Typ)
  - Operating Temperature Range 65 to 175°C



NPN SILICON
POWER DARLINGTON
TRANSISTORS

1400 VOLTS 250 WATTS

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data – representing device characteristics boundaries – are given to facilitate "worst case" design.



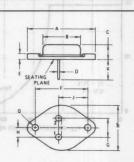
# MAXIMUM RATINGS

hazard agreement and a second servers of the			Unit
Collector-Emitter Voltage	VCEO(sus)	r rebal/1000	Vdc
Collector-Emitter Voltage	VCEV	1400	Vdc
Emitter Base Voltage	VEB	10	Vdc
Collector Current - Continuous - Peak (1)	tot level e	152 9/1T	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	off , No.	Adc
Free Wheel Diode: Forward current - Continuous - Peak	I <sub>F</sub>	24 40	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD g	250 125	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 to +175	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ROJC	0.6	°C/W
Maximum Lead Temperature	TL		°C
for Soldering Purpose:  1/8" from Case for 5 Seconds		275	

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.



STYLE 1: PIN 1. BASE 2. EMITTER CASE COLLECTOR

	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1 550	
8	-	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1 09	0.039	0.043	
E	-	3.43		0.135	
F	29.90	30.40	1 177	1.197	
G	10.67	11 18	0.420	0.440	
H	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11 18	12 19	0 440	0.480	
0	3.84	4.09	0 151	0 161	
R		26.67	-	1.050	

CASE 197-01 MODIFIED TO-3

3

# ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS	FIGURE 2 -		HAD	C COMMENT	Q - T SHUA	014
Collector-Emitter	Sustaining Voltage (Ta	ble 1)	VCEO(sus)	1000			Vdc
	Current d Value, VBE(off) = 1. d Value, VBE(off) = 1.		ICEV	270		0.2	mAdc 905
Emitter Cutoff Current (VEB = 2.0 V, IC = 0)			IEBO	*+>	翗	350	mAdc
SECOND BREAKD	DOWN	/ ], [					01
Second Breakdov	vn Collector Current wi	th base forward biased	IS/b	/	See Fi	gure 16	
Clamped Inductiv	e SOA with Base Reve	rse Biased	RBSOA		See Fi	gure 17	
ON CHARACTER	STICS (1)	4-10					25 - 21 - 5
DC Current Gain (IC = 8 A, VCE = 5 V) (IC = 16 A, VCE = 5 V)			hFE	20 5	01 1	1 T	301
	Saturation Voltage	anupia	VCE(sat)	V BOSVARI	KAR KETTO	5.0	Vdc
Base-Emitter Sat	uration Voltage	FEE - 25	VBE(sat)		-	3.3	Vdc_es
Diode Forward V (IF = 24 A)	oltage	12.5	Vf	111	THE	4.0	Vdc
SWITCHING CHA	The state of the s	119 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				0	5 0
Storage Time		See Table 1	ts	-	HEH	6.0	μs
Fall Time	TC = 25°C	IC = 16 A	tf			2.5	μs
Storage Time	01 1 2 0	IB1 = 3.2 A	ts	107	4.5	1	μs
Fall Time	TC = 100°C	VBE(off) = 5 V	tf	100000	1.7		μs

(1) Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

Figure 1 17 acres to a 1 17 ac

DUTY CYCLE, B = 11/12



0.02

0.01 0.01

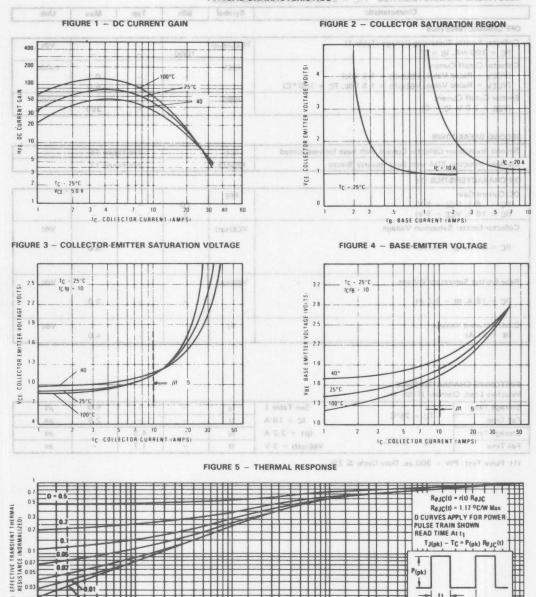
0.02 0.03 0.05

0.2 0.3

0.1

0.5

#### TYPICAL CHARACTERISTICS = OTI EDITERISTOARANO JACIRTOBIA



tı

100

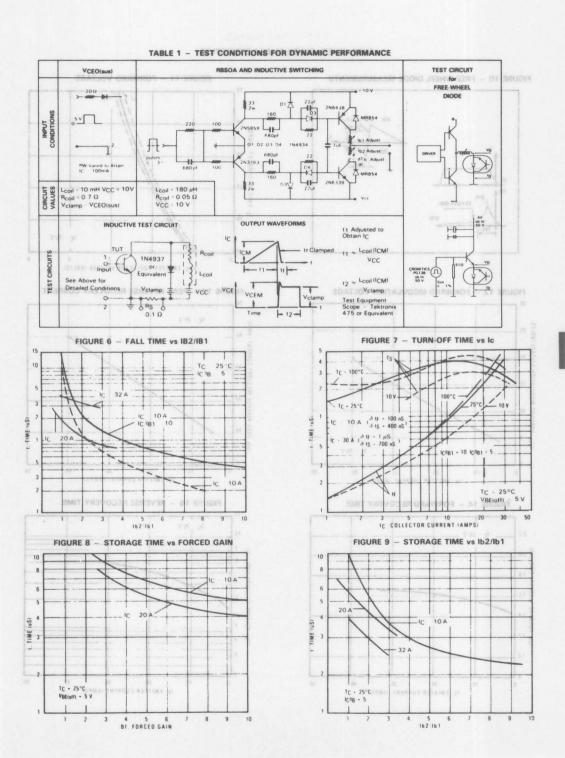
20 30

50

DUTY CYCLE, D = 11/12

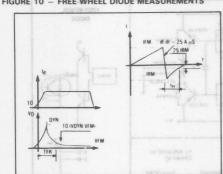
200 300



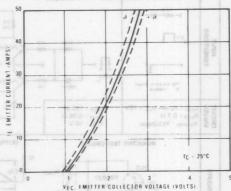


#### FREE-WHEEL DIODE CHARACTERISTICS





#### FIGURE 11 - FORWARD VOLTAGE



#### FIGURE 12 - FORWARD MODULATION VOLTAGE

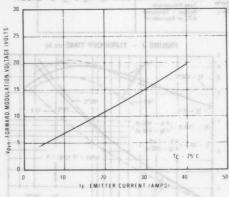
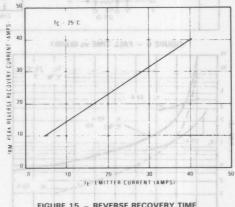


FIGURE 13 - PEAK REVERSE RECOVERY CURRENT



#### FIGURE 14 - FORWARD RECOVERY TIME

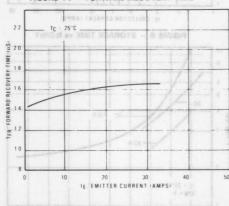
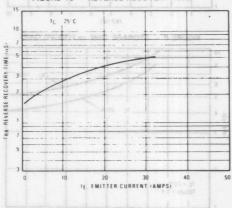
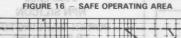


FIGURE 15 - REVERSE RECOVERY TIME



NIX 233501 18

The Safe Operating Area figures shown in Figures 16 and 17 are specifed for these devices under the test conditions shown.



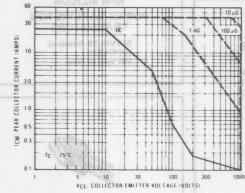


FIGURE 17 - REVERSE BIAS SAFE OPERATING AREA

#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

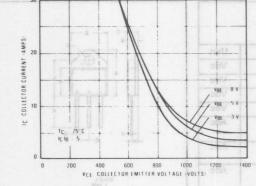
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subject to grater dissipation than the curves indicate.

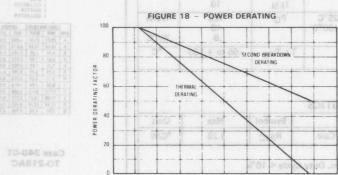
The data of Figure 16 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 16 may be found at any case temperature by using the appropriate curve on Figure 18. Motor Controls

TJ(pk) may be calculated from the data in Figure 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltagecurrent condition allowable during reverse biased turnoff. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 17 gives the RBSOA characteristics.





40

C CASE TEMPERATURE ( C)

160

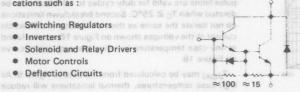


### ADVANCE INFORMATION

#### 30V-01 atsolute as SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS

The BUT50P darlington transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. It is particularly suited for line operated switch-mode applied cations such as tot selave youb not bilev any animit ealed

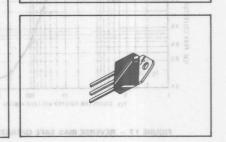
- Switching Regulators of as emaa and statish ton g
- Inverters f angil no awords esputio vari
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits not be alunion od yam pa



#### 8 AMPERES NPN SILICON

#### POWER DARLINGTON TRANSISTORS

500 VOLTS-Vceo(sus) 100 WATTS 850 VOLTS-Vces



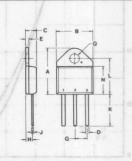
#### MAXIMUM RATINGS (succensition) a benistate

blan ad taum sor Rating sallos adt anorti	Symbol	BUT50P	Unit
Collector-Emiter Voltage & world to	VCEO(sus)	500	Vdc
Collector-Emitter Voltage	VCEX(sus)	850	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage	VEB	8 8	Vdc
Collector Current — Continuous — Peak (1)		1100 8 110 16	Adc
Base Current — Continuous — Peak (1) — ACRES of	IBM	2 4	Adc
Free Wheel Diode : Forward Current — continous — peak	IF IFM	8 16	Adc
Total Power Dissipation @ T <sub>C</sub> =25°C @ T <sub>C</sub> =100°C Derate above 25°C	PD	100 40 .8	Watts W/°C
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to + 150	°C

#### THERMAL CHARACTERISTICS

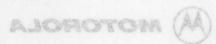
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.25	°C/W

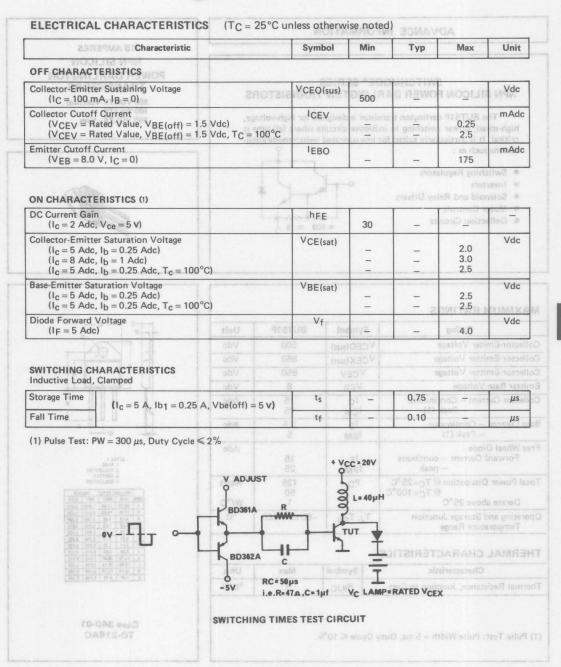
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR

Case 340-01 TO-218AC

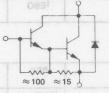




## ADVANCE INFORMATION

## SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits



# 15 AMPERES NPN SILICON POWER DARLINGTON TRANSISTORS

500 VOLTS-Vceo(sus) 100 WATTS 850 VOLTS-Vces



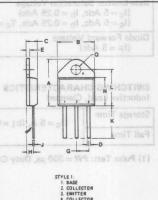
#### MAXIMUM RATINGS

Rating	Symbol	BUT51P	Unit
Collector-Emiter Voltage	VCEO(sus)	500	Vdc
Collector-Emitter Voltage	VCEX(sus)	850	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage	VEB	8	Vdc
Collector Current — Continuous — Peak (1)	ICM	15 25	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	2.5 5	Adc
Free Wheel Diode : Forward Current — continous — peak	IF IFM	15 25	Adc
Total Power Dissipation @ T <sub>C</sub> =25°C @ T <sub>C</sub> =100°C Derate above 25°C	PD	125 50 1	Watts W/°C
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to + 150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1	°C/W

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



Case 340-01 TO-218AC



## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

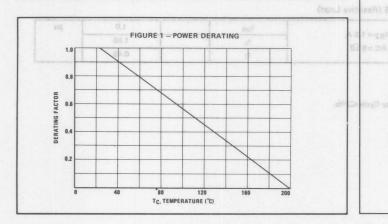
- ... designed for high current, high speed, high power applications.
- HFe min.: 20 at Ic = 10 A
- TF max. = 0.45 µs at lc = 15 A
- Equivalent to BDY58

#### **MAXIMUM RATINGS**

Rat	ting	Symbol	Value	Unit
Collector-Emitter Voltag	e 0.1	VCEO(sus)	125	Vdc
Collector-Base Voltage		V <sub>CBO</sub>	160	Vdc
Emitter-Base Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)		VCEX	160	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )		VCER	140	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)		IC fee)	25 30	Adc Apk
Base-Current continuous	0.5	IB	6	Adc
Total Power Dissipation	@T <sub>C</sub> = 25°C	PD	175	Watts
Operating and Storage Ju Temperature Range	inction	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.0	%C/W

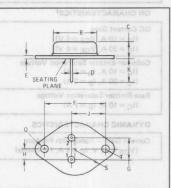


## 25 AMPERES

## NPN SILICON POWER METAL TRANSISTOR

125 VOLTS 175 WATTS





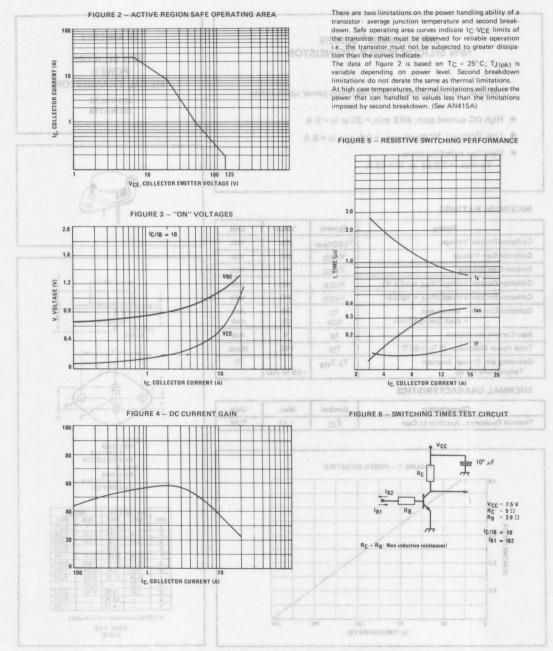
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

	MILLIM		INC	HES
DIM	MIN	MAX	MIN	MAX
В	-	22.23		0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	**	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	-	0.312	-
0	3.84	4.09	0.151	0.161
S	-	13.34	-	0.525
T	-	4.78	-	0.188

Characteristic			Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>		RO	TRANSIST	SEMOS	NEW SITTICOM	
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)		V	CEO(sus)	125		Vdc
Collector Cutoff Current at Reverse Biais: (V <sub>CE</sub> = 160 V, V <sub>BE</sub> = -1.5 V) (V <sub>CE</sub> = 160 V, V <sub>BE</sub> = -1.5 V, T <sub>C</sub> = 125°C)	.eng	31 34 AQUE	CEX	oseqa ngiri ,	1.5	mAdc
Collector-Emitter Cutoff Current (VCE = 100 V)			CEO	0.21	0.1 20 at ic = 10 A	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)			VEBO	7	88YOR of the	v saviup3 e
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)			<sup>I</sup> EBO		0.5	mAdc
SECOND BREAKDOWN					ATIMITA	R MUMEKA
Second Breakdown Collector Current with base for $(V_{CE} = 20 \text{ V}, t = 0.5 \text{ s})$	ward biased	epleV	Is/b	8.75	Plating	Adc
(V <sub>CE</sub> = 48 V, t = 0.5 s)	Vife	128	(eus) 030 <sup>1</sup>	1.0	egenteV to	attector-Emilia
ON CHARACTERISTICS1	Vdc	091	080V		ejasto'	/ sisfi-totaelle
DC Current Gain (I <sub>C</sub> = 10 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 20 A, V <sub>CE</sub> = 4 V)	Vdc	160	hFE X30V	20 V 8	r-=ggV60 angV to	CONTRACTOR AND
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 A, I <sub>B</sub> = 1 A) (I <sub>C</sub> = 20 A, I <sub>B</sub> = 2 A)	Ade	-	/CE(sat)		auguniynag – 11 m 01 > wo1 hasq – 2.0	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 10 A, I <sub>B</sub> = 1 A)	Watts	971	/BE(sat)		of as = oT of the state of the	Vdc
DYNAMIC CHARACTERISTICS		65 to 200	- Bre in		ogneR	Таправишта
Current Gain — Bandwidth Product (V <sub>CE</sub> = 15 V, I <sub>C</sub> = 1 A, f = 4 MHz)			fT	10.0	HARACTERISTIC	MHz
	M/O <sub>b</sub>	1.0	9/6 100m/s		Orandow last nov. Junction to Cesa	strice? lame
SWITCHING CHARACTERISTICS (Resistiv	e Load)					
Turn on Time			ton	st associ	1.0	μs
Storage Time $(V_{CC} = 75 \text{ V. RC} = 5 \Omega)$			t <sub>S</sub>		1.55	767
Fall Time			tf		0.45	
<sup>1</sup> Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2	20/0.			1		
1811 337 DAME 00.05 1						1000
						1.0 %









## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high current, high speed, high power applications.

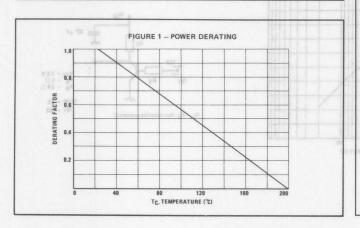
- High DC current gain: HFE min. = 20 at Ic = 6 A
- Low VCE(sat), VCE(sat) max. = 0.6 V at Ic = 6 A
- Very fast switching times:
   T<sub>F</sub> max. = 0.8 μs at Ic = 12 A

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	200	Vdc
Collector-Base Voltage	VCBO	250	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (V <sub>BE</sub> = -1.5 V)	VCEX	250	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	240	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	I <sub>C</sub>	20 25	Adc Apk
Base-Current continuous	IB	4	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	150	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.17	°C/W

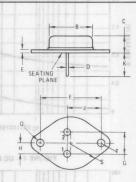


#### 20 AMPERES

#### NPN SILICON POWER METAL TRANSISTOR

200 VOLTS 150 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR
STYLE 2:
PIN 1. BASE
2. COLLECTOR
CASE-EMITTER

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
В		22.23	-	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	11141	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92		0.312	-
0	3.84	4.09	0.151	0.161
S	-	13.34	-	0.525
T	-	4.78	12	0.188

CASE 1-03 (TO-3)

Unit

MHz

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic

Collector-Emitter Sustaining Voltage (IC = 200 mA, IB = 0, L = 25 mH)	VCEO(sus)	200		Vdc
Collector Cutoff Current at Reverse Biais: $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 125^{\circ}\text{C})$	ICEX		1.5 6	mAdc
Collector-Emitter Cutoff Current (VCE = 160 V)	ICEO	Will	1.5	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)	V <sub>EBO</sub>	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)	1 <sub>EBO</sub>	ECTRON ROTTINGS	1.0	mAdc
SECOND BREAKDOWN				
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 30 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 140 \text{ V}, t = 1 \text{ s}$ )	IS/b	5.0 0.15	- 8 SRUDIN	Adc
ON CHARACTERISTICS <sup>1</sup>				0.5
ON CHARACTERISTICS			60	
DC Current Gain (IC = 6 A, VCE = 2 V) (IC = 12 A, VCE = 4 V)	hFE	20 10		
DC Current Gain (IC= 6 A, VCE=2 V)	VCE(sat)	CONTRACTOR OF THE PROPERTY OF	0.6 1.5	Vdc

#### SWITCHING CHARACTERISTICS (Resistive Load)

Current Gain - Bandwidth Product

 $(V_{CE} = 15 \text{ V}, I_{C} = 1 \text{ A}, f = 4 \text{ MHz})$ 

Turn on Time	$I_C = 12 \text{ A}, I_{B1} = I_{B2} = 1.5 \text{ A},$ $(V_{CC} = 150 \text{ V}, \text{RC} = 12.5 \Omega)$	ton		0.8	μs
Storage Time		ts		1.8	J
Fall Time		tf	THE Y	0.4	700

fT

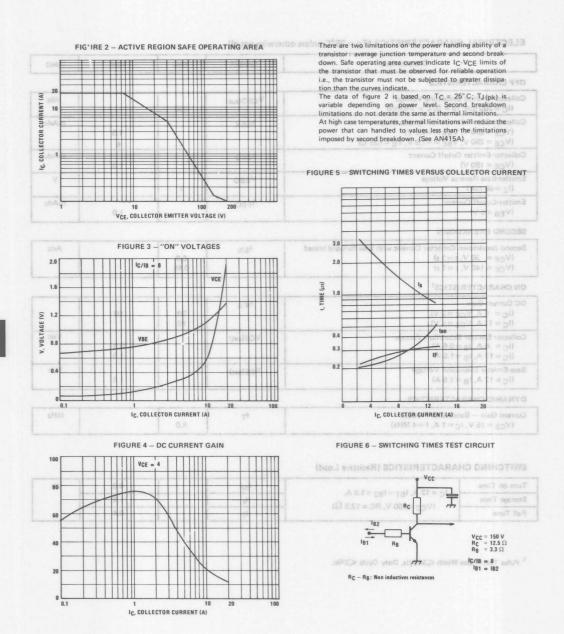
 $^{1}$  Pulse Test: Pulse Width  $\leqslant$ 300  $\mu$ s, Duty Cycle  $\leqslant$ 2%.

8.0

Min.

Symbol

Max.





#### NPN SILICON POWER METAL TRANSISTOR

designed for high speed, high current, high power applications.

- High DC Current gain HFE min 20 @ IC = 8 A
- Very fast switching times

t<sub>F</sub> max. = 0.25 μs @ I<sub>C</sub> = 15 A

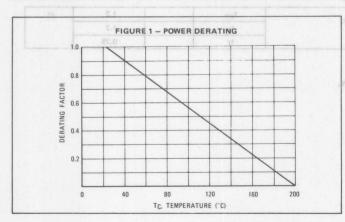
- Low VCE(sat): VCE(sat) max. = 0.6 V, @ IC = 8A
- High VCEO: 160 V.

#### **MAXIMUM RATINGS**

	Rating	Symbol	Value	Unit
Collector-Emitter V	'oltage	VCEO(sus)	160	Vdc
Collector-Base Volt	age	VCBO	220	Vdc
Emitter-Base Volta	ge	VEBO	7	Vdc
Collector-Emitter V	oltage (VBE = -1.5 V)	VCEX	220	Vdc
Collector-Emitter V	$'$ oltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	200	Vdc
Collector-Current -	continuous peak (pw ≤ 10 ms)	I <sub>C</sub>	20 25	Adc Apk
Base-Current contin	uous	IB	5	Adc
Total Power Dissipa	ation @ T <sub>C</sub> = 25 °C	PD	150	Watts
Operating and Store Temperature Rai		T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C.

#### THERMAL CHARACTERISTICS

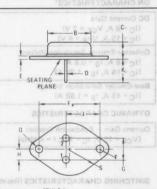
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W



# NPN SILICON POWER METAL TRANSISTOR

20 AMPERES OCC - 30V





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR
STYLE 2:
PIN 1. BASE
2. COLLECTOR
CASE-EMITTER

	MILLIM		INC	
DIM	MIN	MAX	MIN	MAX
В	-	22.23	-	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	-	0.312	
0	3.84	4.09	0.151	0.161
S	-	13.34	-	0.525
T	-	4.78	-	0.188

CASE 1-03 (TO-3)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS1	HOT	TAL THANSIS	am nave	M NUGICIEUM M	VI.
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)		V <sub>CEO(sus)</sub>	160		Vdc
Collector Cutoff Current at Reverse Bias: (V <sub>CE</sub> = 220 V, V <sub>BE</sub> = -1.5 V) (V <sub>CE</sub> = 220 V, V <sub>BE</sub> = -1.5 V, T <sub>C</sub> = 125 °C)	upplications,	ICEX	d, high cur	1.5 6.0	mAdc
Collector-Emitter Cutoff Current (VCE = 130 V)		ICEO	Hee min 2 is	OC Current gein	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)		V <sub>EBO</sub>	A 81 = 51 1.0 = <b>7</b> cem (	max. = 0.25 µs @ VCEtest): VCEtes	Wol s
Emitter-Cutoff Current (VEB = 5 V)		IEBO		V 081 :090V	mAdc

Second Breakdown Collector Current with	pase forward biased	IS/b		6/6/9/11174	Adc
(VCE = 30 V, t = 1 s)	Jinu anit		5	Belief	
(VCE = 140 V, t = 1 s)	2017	- A	0.15	- Madesus	select second

#### ON CHARACTERISTICS1

	-	-	ASSES TO A				-
DC Current Gain		1	hFE		The second secon	V sast-racin	13
(I <sub>C</sub> = 8 A, V <sub>CE</sub> = 2 V) (I <sub>C</sub> = 15 A, V <sub>CE</sub> = 4 V)		220		20 10	- 38 V light ov H	Hactor-Emits	0
Collector-Emitter Saturation Voltage	53V	500	VCE(sat)	12104	it - liBus ademos se	Vdc	19
(IC = 8 A, IB = 0.8 A)		0.5	31		0.6	flactor-Curra	0
(I <sub>C</sub> = 15 A, I <sub>B</sub> = 1.88 A)		25		tan	01 > 1.5		1
Base-Emitter Saturation Voltage	Ada	1 3	VBE(sat)		eurourity	Vdc	8
(I <sub>C</sub> = 15 A, I <sub>B</sub> = 1.88 A)		98		20	1.8	tel Power Dis	-

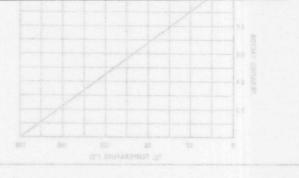
#### DYNAMIC CHARACTERISTICS

Current Gain - Bandwidth Product	fT			MHz
(VCE = 15 V, IC = 1 A, f = 4 MHz)		8 2	HARACTERISTI	HERMAL C

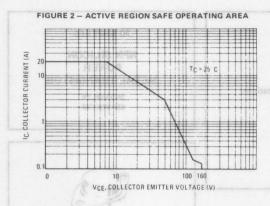
#### SWITCHING CHARACTERISTICS (Resistive Load)

Turn on Time	ge Time $(I_C = 15 \text{ A}, I_{B1} = I_{B2} = 1.88 \text{ A},$ $V_{CC} = 30 \text{ V}, \text{ RL} \approx 2 \Omega)$	ton	1.2	μs
Storage Time		tsataasg asw	04 - 1 INUDIS 1.2	
Fall Time		tf	0.25	

<sup>1</sup> Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤2%.





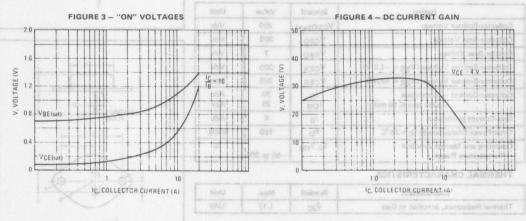


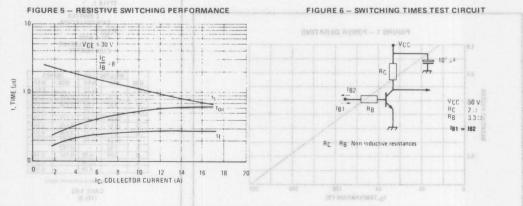
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate  $1_{C^+}V_{CE}$  limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

tion than the curves indicate. The data of figure 2 is based on  $T_C = 25\,^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN415A)

\* Very fest switching times:







## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high voltage, high power applications.

High DC current gain:
 HFE min. = 20 at lc = 5 A

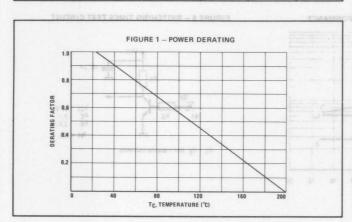
Very fast switching times:
 T<sub>S</sub> max. = 1.5 μs at Ic = 10 A
 T<sub>F</sub> max. = 0.5 μs at Ic = 10 A

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	250	Vdc
Collector-Base Voltage	VCBO	300	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)	VCEX	300	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100Ω)	VCER	290	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	IC ICM	20 25	Adc Apk
Base-Current continuous	IB	4	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	150	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

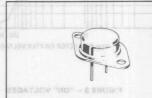
Characteristic 3 4 4 103 .34	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.17	°C/W

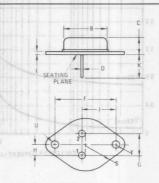


#### 20 AMPERES

#### NPN SILICON POWER METAL TRANSISTOR

250 VOLTS 150 WATTS





STYLE 1:
PIN 1: BASE
2: EMITTER
CASE-COLLECTOR
STYLE 2:
PIN 1: BASE
2: COLLECTOR
CASE-EMITTER

	MILLIMETERS		INC	CHES	
DIM	MIN	MAX	MIN	MAX	
В	-	22.23		0.875	
C	6.35	11.43	0.250	0.450	
D	0.97	1.09	0.038	0.043	
E	Name of the last	3.43		0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	7.92	-	0.312	-	
0	3.84	4.09	0.151	0.161	
S	-	13.34	-	0.525	
T	-	4.78	0	0.188	

CASE 1-03 (TO-3)

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>				
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	VCEO(sus)	250		Vdc
Collector Cutoff Current at Reverse Biais: $(V_{CE} = 300 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 300 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 125^{\circ}\text{C})$	ICEX		1.5 6	mAdo
Collector-Emitter Cutoff Current (VCE = 200 V)	CEO		1.5	mAdo
Emitter-Base Reverse Voltage (IE = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)	IEBO		1.0	mAdo
SECOND BREAKDOWN				
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 30 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 140 \text{ V}, t = 1 \text{ s}$ )	IS/b	5.0 0.15	6r 1602 32N	Adc
ON CHARACTERISTICS <sup>1</sup>	TACES	163 - "ON" VOL	FIGUR	
DC Current Gain (I <sub>C</sub> = 5 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 10 A, V <sub>CE</sub> = 4 V)	hFE 30%	20	60	0.5
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5 A, I <sub>B</sub> = 0.5 A) (I <sub>C</sub> = 10 A, I <sub>B</sub> = 1.25 A)	VCE(sat)		1.0 1.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 10 Å, I <sub>B</sub> = 1.25 A).	VBE(sat)		1,5	Vdc
DYNAMIC CHARACTERISTICS			THILL	- 2
Current Gain — Bandwidth Product (VCE = 15 V, IC = 1 A, f = 4 MHz)	fT	8.0		MHz

#### SWITCHING CHARACTERISTICS (Resistive Load)

Turn on Time	age Time $(V_{CC} = 150 \text{ V, RC} = 15 \Omega)$	ton MAD THERRIES	og _   amuaia 0.7	μs
Storage Time		t <sub>s</sub>	1,5	7,005
Fall Time		tf	0.5	

<sup>1</sup> Pulse Test: Pulse Width  $\leq$ 300  $\mu$ s, Duty Cycle  $\leq$ 2%.

28 (St

IC COLLECTOR SURRENT (A)

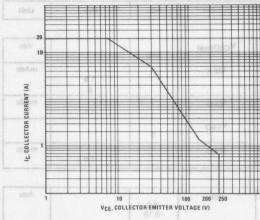


FIGURE 3 - "ON" VOLTAGES

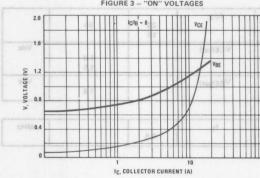


FIGURE 4 - DC CURRENT GAIN

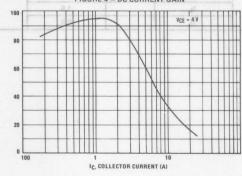


FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA TO RESIDE OF STATE ACTIVE REGION SAFE OPERATING AREA

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on T<sub>C</sub> = 25°C; T<sub>J</sub>(pk) is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE

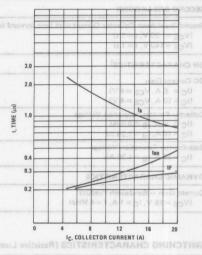
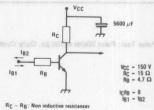


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT





## SWITCHMODE<sup>A</sup> SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high current, high power applications.

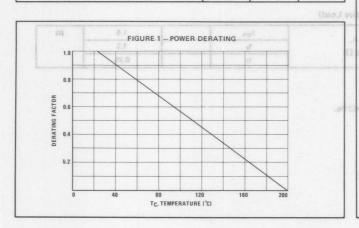
- High DC current gain:
  - HFE min. = 20 at Ic = 25 A = 10 at Ic = 50 A
- Low VCE(sat):
  - VCE(sat) max. = 0.6 V at Ic = 25 A = 1.2 V at Ic = 50 A
- Very fast switching times:
- $T_F = 0.25 \,\mu s$  at  $I_C = 50 \,A$

#### **MAXIMUM RATINGS**

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	1.5	VCEO(sus)	125	Vdc
Collector-Base Voltage		Vсво	160	Vdc
Emitter-Base Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -	-1.5 V)	VCEX	160	Vdc
Collector-Emitter Voltage (RBE = 1	00Ω)	VCER	150	Vdc
Collector-Current — continuous — peak (pw ≤ 10	ms)	I <sub>C</sub>	50 60	Adc Apk
Base-Current continuous		IB	10	Adc
Total Power Dissipation $@T_C = 25^\circ$	c	PD	250	Watts
Operating and Storage Junction Temperature Range		T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

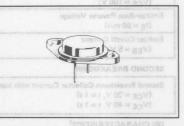
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	0.7	°C/W

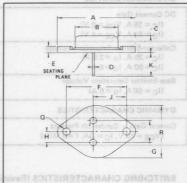


#### 50 AMPERES

## NPN SILICON POWER METAL TRANSISTOR

125 VOLTS 250 WATTS





STYLE 1:
PIN 1. BASE
PIN 2. EMITER
CASE COLLECTOR DIT SOCIOLO

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01 MODIFIED TO 3

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	8 Min.	Нот Мах.	Unit
OFF CHARACTERISTICS <sup>1</sup>	RAMSISTOR	POWER T	NPN SILICON	
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	VCEO(sus)	1125 dg	ed for high speed, it	obV design
Collector Cutoff Current at Reverse Biais: (V <sub>CE</sub> = 140 V, V <sub>BE</sub> = -1.5 V) (V <sub>CE</sub> = 140 V, V <sub>BE</sub> = -1.5 V, T <sub>C</sub> = 125°C)	ICEX	6 A	C curren 0.6 at le = 1 at le = 1	mAdc
Collector-Emitter Cutoff Current (VCE = 100 V)	ICEO	N. 0	3.0 (328) 3.3	mAdc
Emitter-Base Reverse Voltage (IE = 50 mA)	VEBO	A 03 = of 18	V 2.1 =	V Varual 6
Emitter-Cutoff Current (VEB = 5 V)	IEBO	А	= 0.25 µs at lc = 50 0.1	mAdc

#### SECOND BREAKDOWN

Second Breakdown Collector Current with base for (VCF = 20 V, t = 1 s)	rward biased	quiaV	IS/b	12	gelásifi	Adc
$(V_{CE} = 20 \text{ V}, t = 1 \text{ s})$	Vdc	125	(CEG(sus)	1.5	er Voltage	ollector-Emits

#### ON CHARACTERISTICS1

	The second secon	Control of the contro
Vde	Day hFE X3DV	20 (V F r-= 38 V) series v time-rotes
	VCER 150	10 (Ω DD = 3gR) spateV retrimination
Add	OB VCE(sat)	accoming — continuous Vdc ×
	10 10	1.2 augunitrop transition
Watts	VBE(sat)	of ac = of polynamica Vdc
	Vde Add AQN AQN	25V 081

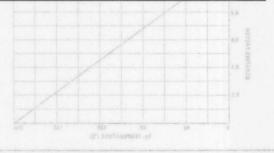
#### DYNAMIC CHARACTERISTICS

Current Gain — Bandwidth Product	fT		HARACTERISTICS	MHz
$(V_{CE} = 15 \text{ V}, I_C = 2 \text{ A}, f = 4 \text{ MHz})$		8.0		

#### SWITCHING CHARACTERISTICS (Resistive Load)

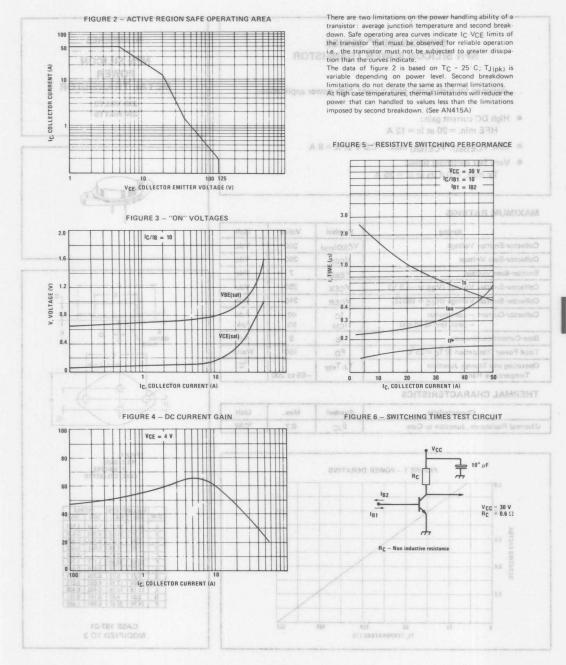
Turn on Time	PIN I DAS SOLD TO A LOCAL SOLD TO A	ton	1.5	μs
Storage Time	$I_C = 50 \text{ A}, I_{B1} = I_{B2} = 5 \text{ A},$	t <sub>s</sub>	1.2	
Fall Time	$(V_{CC} = 30 \text{ V, RC} = 0.6 \Omega)$	te	0.25	2.7

<sup>&</sup>lt;sup>1</sup> Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2%.



CASE 197-01







## SWITCHMODE<sup>®</sup> SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high current, high power applications.

- High DC current gain:
   HFE min. = 20 at Ic = 12 A
- Low VCE(sat), VCE(sat) max. = 0.6 V at Ic = 8 A
- Very fast switching times:

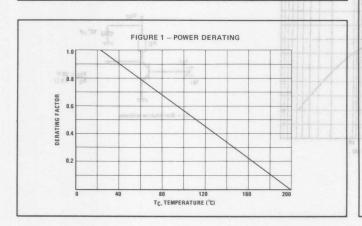
TF max. =  $0.4 \,\mu s$  at  $Ic = 25 \,A$ 

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	200	Vdc
Collector-Base Voltage	Vсво	250	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (V <sub>BE</sub> = -1.5 V)	VCEX	250	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	240	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	I <sub>C</sub>	40 50	Adc Apk
Base-Current continuous	IB	8	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	150	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

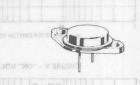
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	0.7	°C/W

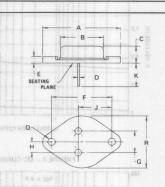


#### 40 AMPERES

NPN SILICON POWER METAL TRANSISTOR

> 200 VOLTS 250 WATTS





STYLE 1: PIN 1. BASE 2. EMITTER CASE. COLLECTOR

	MILLIA	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	38.35	39.37	1.510	1.550	
В	19.30	21.08	0.760	0.830	
C	6.35	7.62	0.250	0.300	
D	1.45	1.60	0.057	0.063	
E	174.1	3.43		0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	24.89	26.67	0.980	1.050	

CASE 197-01 MODIFIED TO 3

#### **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	田	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>					0.0
Collector-Emitter Sustaining Voltage	There are from the are for the construction are constructed and construction are constructed are for the construction and construction are constructed as a construction are con	VCEO(sus)	200		Vdc
Collector Cutoff Current at Reverse Biais: $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 12 \text{ V})$	near add _a.s.	CEX	M.	3.0 12.0	mAdc
Collector-Emitter Cutoff Current (VCE = 160 V)	vensible dep	ICEO		3.0	mAdc
Emitter-Base Reverse Voltage		VEBO	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)		IEBO		1.0	mAdc
SECOND BREAKDOWN	a shudis				
Second Breakdown Collector Current with $(V_{CE} = 20 \text{ V}, t = 1 \text{ s})$ $(V_{CE} = 140 \text{ V}, t = 1 \text{ s})$	base forward biased	IS/b	12 0.15	0.50V	Adc
ON CHARACTERISTICS <sup>1</sup>	or .	Oneyawa.	one man a non	unia	
DC Current Gain $(I_C = 12 \text{ A}, V_{CE} = 2 \text{ V})$ $(I_C = 25 \text{ A}, V_{CE} = 4 \text{ V})$	9.5	hFE	20	60	201
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 12 A, I <sub>B</sub> = 1,2 A) (I <sub>C</sub> = 25 A, I <sub>B</sub> = 3 A)	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	VCE(sat)		0.6 1.5	31 Vdc
Base-Emitter Saturation Voltage $(I_C = 25 \text{ A}, I_B = 3 \text{ A})$		VBE(sat)		1.5	Vdc
DYNAMIC CHARACTERISTICS	E,a	HIXT III	171-17		10 3

#### SWITCHING CHARACTERISTICS (Resistive Load)

Current Gain - Bandwidth Product (V<sub>CE</sub> = 15 V, I<sub>C</sub> = 2 A, f = 4 MHz)

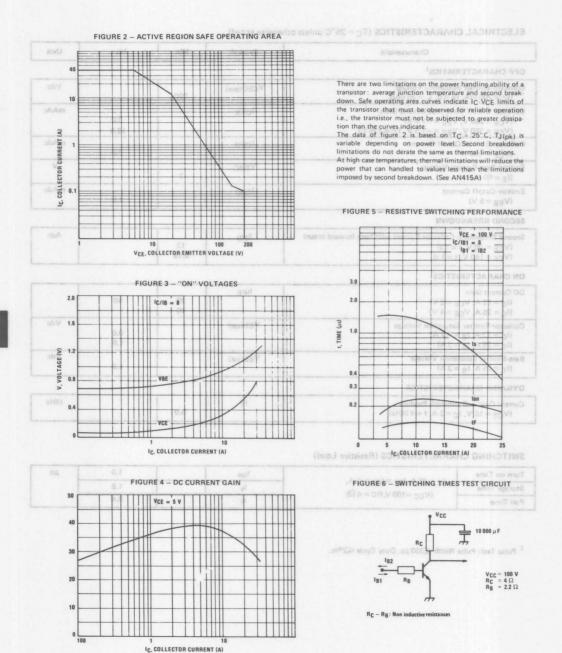
Turn on Time	125 A 12 A	ton		1.0	μs
Storage Time	$I_C = 25 \text{ A}, I_{B1} = I_{B2} = 3 \text{ A},$	ts	CINHUU RU - P INC	1.8	
all Time	$(V_{CC} = 100 \text{ V,RC} = 4 \Omega)$	tf	V = 30/ 1	0.4	48

 $<sup>^1</sup>$  Pulse Test: Pulse Width  ${\leqslant}300\,\mu\text{s}$  , Duty Cycle  ${\leqslant}2^{\text{O}}\!/\text{o}$  .

accompanion with respect to g = 2g - 2g

8.0







## SWITCHMODE<sup>A</sup> SERIES NPN SILICON POWER TRANSISTOR

- ... designed for high speed, high current, high power and low cost applications.
- High DC current gain: HFE min. = 15 at Ic = 20 A
- Low VCE(sat): VCE(sat) max. = 1.0 V at Ic = 20 A

= 1.8 V at Ic = 40 A

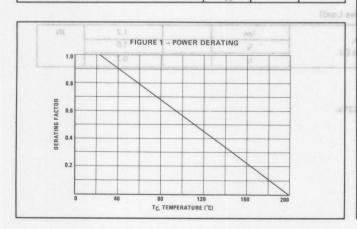
• Very fast switching times: Τ<sub>F</sub> max. = 0.2 μs at Ic = 40 A

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 8.0	VCEO(sus)	160	Vdc
Collector-Base Voltage	VCBO	220	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)	VCEX	220	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	200	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	I <sub>C</sub> (see	50 40 50	Adc Apk
Base-Current continuous	IB	10	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	250	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

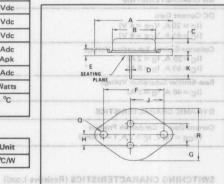
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	0.7	°C/W



### 40 AMPERES

NPN SILICON POWER METAL TRANSISTOR





STYLE 1:
PIN 1. BASE PRIT NO PROT

A B = CRI = FRI .A CR = 2. EMITTER

CASE. COLLECTOR STAT PROTORS

T.O = OR .V OR = OV

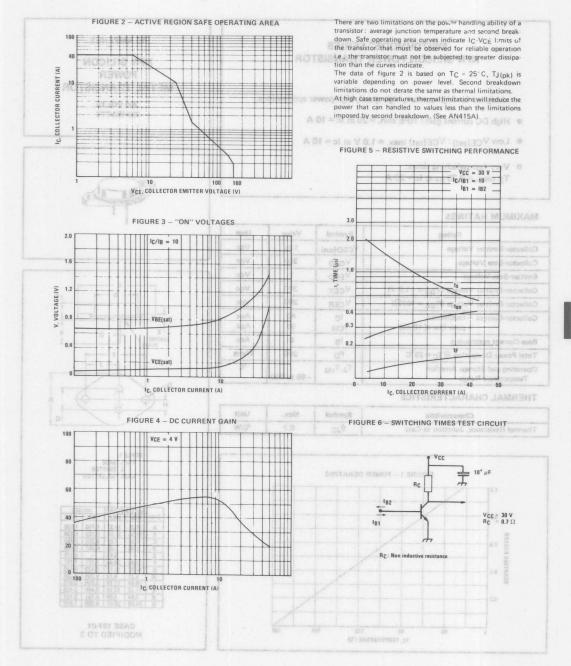
	MILLIA	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
0	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01 MODIFIED TO 3

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) Characteristic Unit Min. Symbol Max. OFF CHARACTERISTICS1 Collector-Emitter Sustaining Voltage VCEO(sus) Vdc $(I_C = 200 \text{ mA}, I_B = 0, L = 25 \text{ mH})$ 160 Collector Cutoff Current at Reverse Biais: ICEX mAdc $(V_{CE} = 220 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 220 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 125^{\circ}\text{C})$ 3.0 12.0 Collector-Emitter Cutoff Current CEO mAdc (V<sub>CE</sub> =130 V) 30 Emitter-Base Reverse Voltage VEBO $(I_E = 50 \text{ mA})$ Emitter-Cutoff Current mAdc IEBO (VEB = 5 V) 1.0 SECOND BREAKDOWN Second Breakdown Collector Current with base forward biased Is/b Adc $(V_{CE} = 25 \, V, t = 0.5 \, s)$ 10 (V<sub>CE</sub> =140 V, t = 0.5 s) 0.3 ON CHARACTERISTICS1 DC Current Gain HEE (IC = 20 A, VCE = 4 V) 15 60 (IC = 40 A, VCE = 4 V) 10 Collector-Emitter Saturation Voltage Vdc VCE(sat) (IC = 20 A, IB = 2 A) 1.0 (IC = 40 A, IB = 5 A) 1.8 Base-Emitter Saturation Voltage Vdc VBE(sat) 2.0 $(I_C = 40 A, I_B = 5 A)$ DYNAMIC CHARACTERISTICS Current Gain - Bandwidth Product MHz $(V_{CE} = 15 \text{ V}, I_{C} = 2 \text{ A}, f = 4 \text{ MHz})$ 8.0 SWITCHING CHARACTERISTICS (Resistive Load) Turn on Time 1.2 ton Ms IC = 40 A, IB1 = IB2 = 5 A, 1.0 Storage Time ts $(V_{CC} = 30 \text{ V, RC} = 0.75 \Omega)$ Fall Time 0.2 tr <sup>1</sup> Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2%.

CASE 197-01







## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high current, high speed, high power applications.

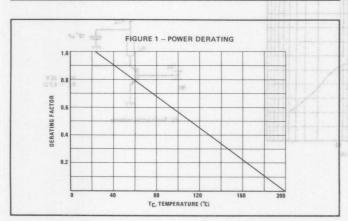
- High DC current gain: HFE min. = 20 at Ic = 10 A
- Low VCE(sat): VCE(sat) max. = 1.0 V at Ic = 10 A
- Very fast switching times:
   T<sub>F</sub> max. = 0.35 μs at Ic = 20 A

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	125	Vdc
Collector-Base Voltage	VCBO	300	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)	VCEX	300	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	290	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	I <sub>C</sub>	40 50	Adc Apk
Base-Current continuous	Isa IB	8	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	250	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

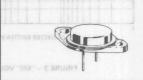
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	$\theta_{\text{JC}}$	0.7	°C/W

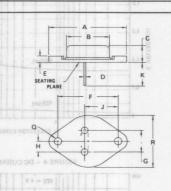


#### 40 AMPERES

#### NPN SILICON POWER METAL TRANSISTOR

250 VOLTS 250 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	1-	3.43	-	0.135
F	29.90	30.40	1.177	1,197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01 MODIFIED TO 3

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) 3390 3342 MOIDER SYNDA - 5 394084

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>				0.0
Collector-Emitter Sustaining Voltage	VCEO(sus)	250		Vdc
Collector Cutoff Current at Reverse Biais:  (VCE = 300 V, VBE = -1.5 V)  (VCE = 300 V, VBE = -1.5 V, TC = 125°C)	CEX	1/1	3.0 12.0	mAdc
Collector-Emitter Cutoff Current (VCE = 200 V)	CEO		3.0	mAdc
Emitter-Base Reverse Voltage (IE = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)	IEBO		1.0	mAdc
SECOND BREAKDOWN				
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 20 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 140 \text{ V}, t = 1 \text{ s}$ )	S/b (9) \$100 Y 3	0.15	01 V26, 100	Adc
ON CHARACTERISTICS <sup>1</sup>	TAGES	LTONNO = 03	FIGURE	
DC Current Gain (I <sub>C</sub> = 10 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 20 A, V <sub>CE</sub> = 4 V)	hFE	20	60	0.5
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 A, I <sub>B</sub> = 1 A) (I <sub>C</sub> = 20 A, I <sub>B</sub> = 2.5 A)	VCE(sat)		1.0 1.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 40 A, I <sub>B</sub> = 4 A)	V <sub>BE</sub> (sat)		1.5	Vdc
DYNAMIC CHARACTERISTICS	anv I		THEFT	
Current Gain — Bandwidth Product (V <sub>CE</sub> = 15 V, I <sub>C</sub> = 2 A, f = 4 MHz)	fŢ	8.0		MHz

#### SWITCHING CHARACTERISTICS (Resistive Load)

Turn on Time	I <sub>C</sub> = 20 A, I <sub>B1</sub> = I <sub>B2</sub> = 2.5 A,	ton many many	0.8	μs
Storage Time		ts	1.1	7.02
Fall Time	$(V_{CC} = 100 \text{ V,RC} = 5 \Omega)$	tf	0.35	



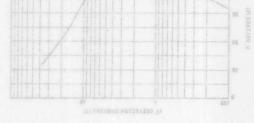
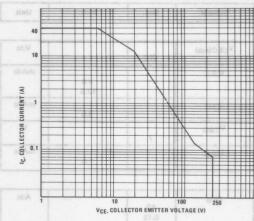


FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA INTO SERVING OF SERVING AND SERVI



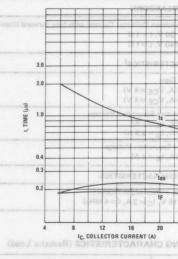
transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

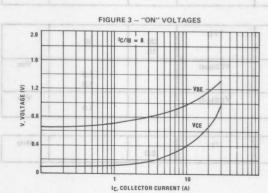
The data of figure 2 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown

There are two limitations on the power handling ability of a

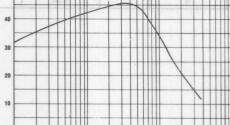
The data of figure 2 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE

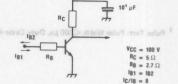








IC, COLLECTOR CURRENT (A)



R<sub>C</sub> - R<sub>B</sub>: Non inductive resistances

3

VOLTAGE (V)



## SWITCHMODE<sup>A</sup> SERIES NPN SILICON POWER TRANSISTOR

designed for high current, high speed, high power applications.

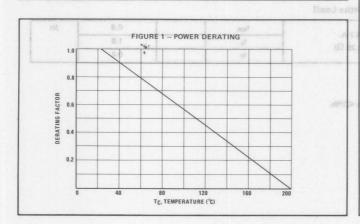
- High DC current gain: HFE min. = 15 at Ic = 8 A
- Low VCE(sat), VCE(sat) max. = 0.8 V at Ic = 8 A
- Very fast switching times:  $T_F = 0.4 \mu s$  at Ic = 16 A

#### **MAXIMUM RATINGS**

Rating	1.2	Symbol	Value	Unit
Collector-Emitter Voltage	0.15	VCEO(sus)	325	Vdc
Collector-Base Voltage		VCBO	400	Vdc
Emitter-Base Voltage	7	VEBO	7	Vdc
Collector-Emitter Voltage (VBE =	=-1.5 V)	VCEX	400	Vdc
Collector-Emitter Voltage (RBE =	= 100Ω)	VCER	390	Vdc
Collector-Current — continuous — peak (pw ≤ 1	10 ms)	I <sub>C</sub>	30 40	Adc Apk
Base-Current continuous		IB	6	Adc
Total Power Dissipation $@T_C = 2$	5°C	PD	250	Watts
Operating and Storage Junction Temperature Range		T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	0.7	°C/W

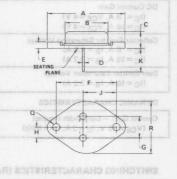


#### 30 AMPERES

## NPN SILICON POWER METAL TRANSISTOR

325 VOLTS 250 WATTS

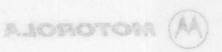




STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
8	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01 MODIFIED TO 3



22939MA O Characteristic		Symbol	A- Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>		TRANSISTOR	POWER	NPN SILICON	
Collector-Emitter Sustaining Voltage (IC = 200 mA, IB = 0, L = 25 mH)		VCEO(sus)	325		Vdc
Collector Cutoff Current at Reverse Biais: ( $V_{CE} = 400 \text{ V}$ , $V_{BE} = -1.5 \text{ V}$ ) ( $V_{CE} = 400 \text{ V}$ , $V_{BE} = -1.5 \text{ V}$ , $T_{C} = 125^{\circ}\text{C}$ )	cations.	d, high xaoler appli 5 at lo = 3 A	it, high spei	3.0 12	mAdc
Collector-Emitter Cutoff Current (VCE = 260 V)		A de of the V	max. = 0.8	VCE(ea 0.6 VCE(sat	mAdo
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)		V <sub>EBO</sub>	-	fast switching time c = 0.4 us at lc = 16	
Emitter-Cutoff Current (VEB = 5 V)		1 <sub>EBO</sub>		1.0	mAdo

#### SECOND BREAKDOWN

Second Breakdown Collector Current with base forward biased		Is/b			Adc
(V <sub>CE</sub> = 20 V, t = 1 s)	syls:V	Symbol	12	Rating	
(V <sub>CE</sub> = 140 V, t = 1 s)	328	Vesetime	0.15		mä-votenlie

#### ON CHARACTERISTICS1

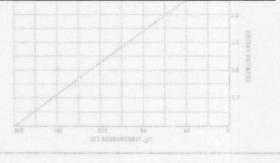
DC Current Gain	201	hee	Egg 110 V 501 (0 - 150 / 0 / 1
(I <sub>C</sub> = 8 A, V <sub>CE</sub> = 4 V)	Vde	VCEX 400	15/ 8.t = agV) 60 rioV rest management
(I <sub>C</sub> = 16 A, V <sub>CE</sub> = 4 V)	Vde	Votes Del	Sollector-Em ther Voitses (Age = 1002) 8
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 8 A, I <sub>B</sub> = 1.6 A) (I <sub>C</sub> = 16 A, I <sub>B</sub> = 3.2 A)	Ade Aplt	VCE(sat)	(sm 07 > wn 0.8 1.0
Base-Emitter Saturation Voltage (IC = 16 A, IB = 3.2 A)	Watte	VBE(sat)	Vdc otal Power Dissipation 7.5 To = 25 C

Current Gain — Bandwidth Product (V <sub>CE</sub> = 15 V, I <sub>C</sub> = 2 A, f = 4 MHz)		fT	8.0	HARACTERISTIC	MHz
	) I MIRS	Symbol I Wax. I		(Therserearistic	

#### SWITCHING CHARACTERISTICS (Resistive Load)

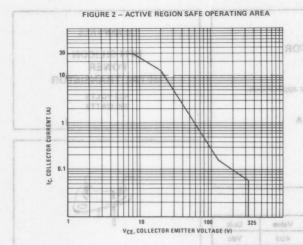
Turn on Time	SUSTEENING TO A LEGISLATION OF THE STATE OF	ton	0.8	μs
Storage Time	IC = 16 A, I <sub>B1</sub> = I <sub>B2</sub> = 3.2 A,	t <sub>s</sub>	1.8	
Fall Time (V <sub>CC</sub> =100 V,RC =6.25 Ω)	tf	, 0.4	2.1	

 $<sup>^{1}</sup>$  Pulse Test: Pulse Width  $\leqslant$ 300  $\mu$ s, Duty Cycle  $\leqslant$ 2%.



CASE 197-01 MODIFIED TO 3

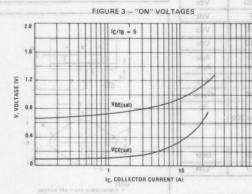


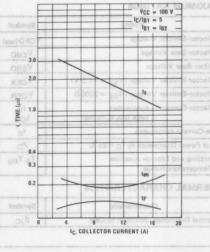


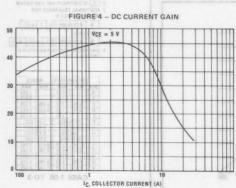
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

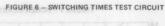
The data of figure 2 is based on  $T_C = 25^{\circ}C$ ;  $T_J(p_k)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

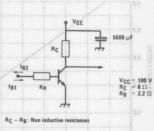
#### FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE













## SWITCHMODE<sup>♠</sup> SERIES NPN SILICON POWER TRANSISTOR

... designed for high current, high speed, high power applications.

- Low VCE(sat), VCE(sat) max. = 1.0 V at Ic = 12 A
- Very fast switching times:

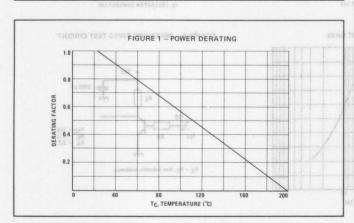
TF max. =  $0.9 \mu s$  at Ic = 12 A

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit Unit
Collector-Emitter Voltage	VCEO(sus)	400	Vdc
Collector-Base Voltage	VCBO	450	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)	VCEX	450	Vdc
Collector-Emitter Voltage (RBE = 100 $\Omega$ )	VCER	440	Vdc
Collector-Current – continuous – peak (pw ≤ 10 ms)	I <sub>C</sub> I <sub>CM</sub>	20 30	Adc Apk
Base-Current continuous	IB	4	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	250	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

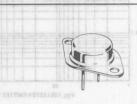
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	0.7	°C/W

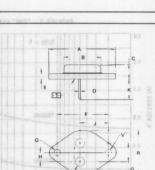


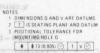
#### 20 AMPERES

NPN SILICON POWER METAL TRANSISTOR

> 400 VOLTS 250 WATTS







	MILLIMETERS		INC	CHES	
DIM	MIN	MAX	MIN	MAX	
A	133	39.37		1.550	
В		21.08	Land I	0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E		3.43	- 1	0.135	
F	30.15	BSC	1.187	BSC	
G	10.92	BSC	0.430	BSC	
H	5.46	BSC	0.215	BSC	
J	16.89	BSC	0.665	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R		26.67		1,050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

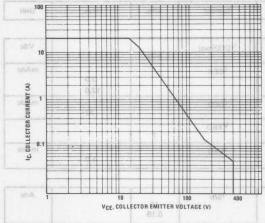
Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>				
Collector-Emitter Sustaining Voltage $(I_C = 200 \text{ mA}, I_B = 0, L = 25 \text{ mH})$	VCEO(sus)	400		Vdc
Collector Cutoff Current at Reverse Biais: ( $V_{CE} = 450 \text{ V}$ , $V_{BE} = -1.5 \text{ V}$ ) ( $V_{CE} = 450 \text{ V}$ , $V_{BE} = -1.5 \text{ V}$ , $T_{C} = 125^{\circ}\text{C}$ )	ICEX	MI	3.0 12.0	mAdo
Collector-Emitter Cutoff Current (VCE = 320 V)	ICEO		30	mAde
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)	IEBO		1.0	mAde
SECOND BREAKDOWN				
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 20 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 140 \text{ V}, t = 1 \text{ s}$ )	1s/b soars	12 0.15	18 19 19 19 19 19 19 19 19 19 19 19 19 19	Add
ON CHARACTERISTICS <sup>1</sup>	230AT	30V "NO" - £ 3	лорія	
DC Current Gain (I <sub>C</sub> = 6 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 12 A, V <sub>CE</sub> = 4 V)	hFE (market	15	60	2
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 6 A, I <sub>B</sub> = 1.2 A) (I <sub>C</sub> = 12 A, I <sub>B</sub> = 2.4 A)	VCE(sat)		0.6 1.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 12 A, I <sub>B</sub> = 2.4 A)	VBE(sat)		1.5	Vdc
DYNAMIC CHARACTERISTICS				1 8
Current Gain – Bandwidth Product (VCB = 15 V, IC = 2 A, f = 4 MHz)	fT	8.0		MHz

Turn on Time	12 - 12 0 12 - 12 - 24 0	ton grap mansus	1.6 FIGURE - DO	μs
Storage Time	I <sub>C</sub> = 12 A, I <sub>B1</sub> = I <sub>B2</sub> = 2.4 A,	t <sub>s</sub>	3.0	
Fall Time	$(V_{CC} = 120 \text{ V, RC} = 8.3 \Omega)$	tf	0.9	

(A) THERROD RETURNEY (A)

 $^{1}$  Pulse Test: Pulse Width  $\leqslant$  300  $\mu$ s, Duty Cycle  $\leqslant$  2%.

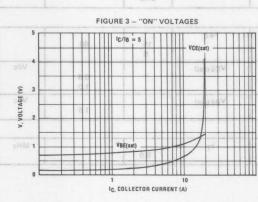


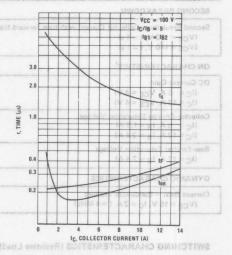


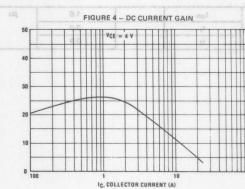
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on  $T_C = 25$  C,  $T_{J(pk)}$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

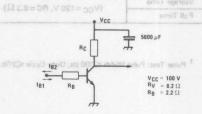
FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE











R<sub>C</sub> - R<sub>B</sub>: Non inductive resistances



### SWITCHMODE<sup>A</sup> SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high voltage, high power applications.

- Low VCE(sat), VCE(sat) max. = 1.5 V at Ic = 8 A
- Very fast switching times: TF max. = 0.8  $\mu$ s at Ic = 8 A

#### 15 AMPERES

NPN SILICON
POWER
METAL TRANSISTOR

325 VOLTS 150 WATTS

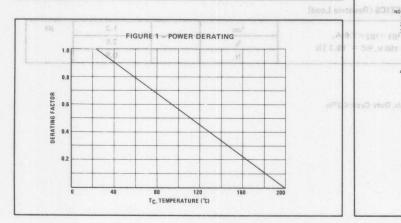


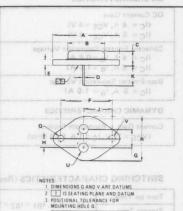
#### **MAXIMUM RATINGS**

Rating	3	Symbol	Value	Unit
Collector-Emitter Voltage	0.15	VCEO(sus)	325	Vdc
Collector-Base Voltage		VCBO	400	Vdc
Emitter-Base Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -2.5 V)		VCEX	400	Vdc
Collector-Emitter Voltage (F	$R_{BE} = 100 \Omega$	VCER	390	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)		I <sub>C</sub>	15 20	Adc Apk
Base-Current continuous		IB	3	Adc
Total Power Dissipation @ T	C = 25 °C	PD	150	Watts
Operating and Storage Junct Temperature Range	tion	T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	$\theta_{\rm JC}$	1.17	°C/W





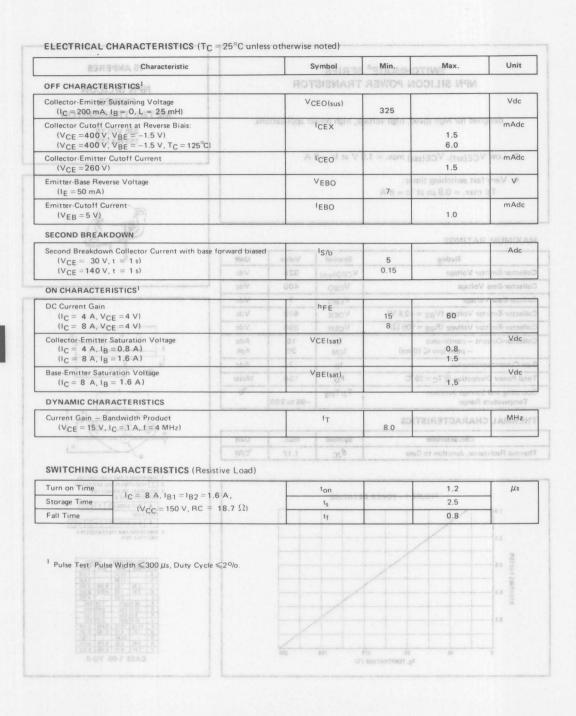
♦ \$ 13 (0 005) ⓒ T V ⓒ

FOR LEADS

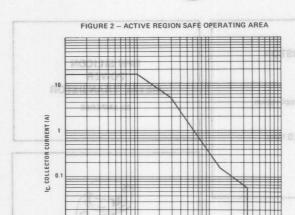
\$ 0 13 (0 005) ⓒ T V ⓒ Q ⓒ

4 DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973

	MILLIA	METERS	INC	HES	
MIG	MIN	MAX	MIN	MAX	
A	-	39.37	-	1,550	
В	-	21.08	100	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	-	3.43	S -	0.135	
F	30.15 BSC		1.187 BSC		
G	10.92 BSC		0.430 BSC		
H	5.48	BSC	0.215 BSC		
J	16.89	BSC	0.665 BSC		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	



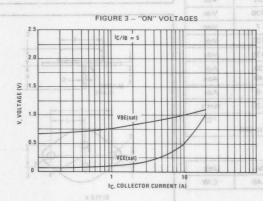




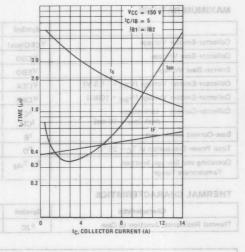
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

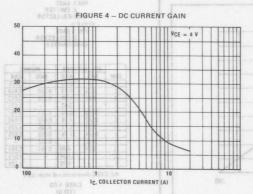
The data of figure 2 is based on  $T_C=25^{\circ}$  C;  $T_{J}(p_k)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

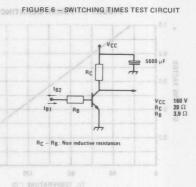
FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE



VCE. COLLECTOR EMITTER VOLTAGE (V)









#### NPN SILICON POWER METAL TRANSISTOR

... designed for high speed, high current, high power application.

- High current gain bandwidth product Ft min. = 8.0 MHz
- High DC current gain HFE min. 15 @ I<sub>C</sub> = 12 A.
   Very fast switching times

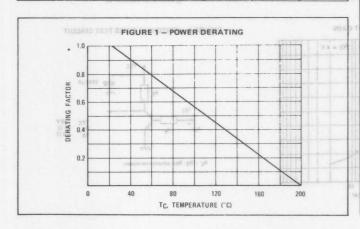
 $t_F max. = 0.25 \mu s @ I_C = 20 A$ 

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	90	Vdc
Collector-Base Voltage	VCBO	120	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -1.5 V)	VCEX	120	Vdc
Collector-Emitter Voitage (RBE = 10002)	VCER	110	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	ICM	30 40	Adc Apk
Base-Current continuous	I <sub>B</sub>	6	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 ° C	PD	120	Watts
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to 200	°C

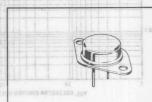
#### THERMAL CHARACTERISTICS

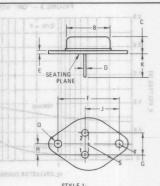
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θЈС	1.46	· C/W



#### NPN SILICON POWER METAL TRANSISTOR

30 AMPERES





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR
STYLE 2:
PIN 1. BASE
2. COLLECTOR
CASE-EMITTER

4	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
В		22.23	-	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	181	3.43	1	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	-	0.312	-
0	3.84	4.09	0.151	0.161
S	1121	13.34	+	0.525
T	-	4.78	+	0.188

#### 2

Vdc

2.5

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25 °C unless otherwise noted) ALTA HERO BRAZE MOIDER EVITDA — S BRUDIA

s to yillide gnillbrain reway an Characteristic in own are shariff	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				30
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	VCEO(sus)	90		Vdc
Collector-Emitter Cutoff Current at Reverse dias Voltage $(V_{CE} = 120 \text{ V, } V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 120 \text{ V, } V_{BE} = -1.5 \text{ V, } T_{C} = 125 ^{\circ}\text{ C})$			1 5	mAdc
Collector-Emitter Cutoff Current (VCE = 70 V)	ICEO	1/11	1	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (VEB = 5 V)	IEBO	00.	gr 1	mAdc

#### SECOND BREAKDOWN

Second Breakdown Collector Current with base forward biased (VCE = 45 V, t = 1 s) (VCE = 30 V, t = 1 s) RUD DO = 4 3 RUD DO	¹S/b	1 BDATJ <b>A</b> V "W	FIGURE 3 – "C	Adc
ON CHARACTERISTICS	CHAR			
DC Current Gain (I <sub>C</sub> = 12 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 20 A, V <sub>CE</sub> = 4 V)	hFE	15 8	45	3.1
Collector-Emitter Saturation Voltage (IC = 12 A, IB = 1.2 A) (IC = 20 A, IB = 2.5 A)	VCE(sat)		1.2	Vdc S

Base-Emitter Saturation Voltage
(I <sub>C</sub> = 20 A, I <sub>B</sub> = 2.5 A)

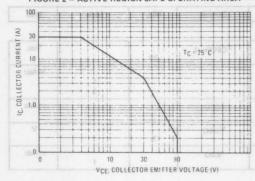
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product	fT			MHz
(V <sub>CE</sub> = 15 V, I <sub>C</sub> = 1 A, f = 4 MHz)	00 00 0	8	61	

VBE(sat)

#### SWITCHING CHARACTERISTICS (Resistive Load)

Turn on Time	I <sub>C</sub> = 20 A, I <sub>B1</sub> = I <sub>B2</sub> = 2.5 A, V <sub>CE</sub> = 30 V, RC = 1.5 Ω)	30 ton CORRE	TOUTHOTING I	IVITE 1.2 8 - 6	E NUO µs
Storage Time		ts		1.0	0
Fall Time		tf		0.25	

Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%.



There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate I\_C-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on  $T_C = 25\,^{\circ}C$ ;  $T_J(p_k)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN415A)

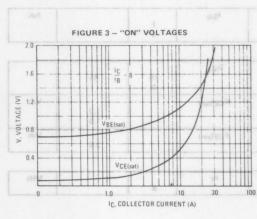


FIGURE 4 – DC CURRENT GAIN

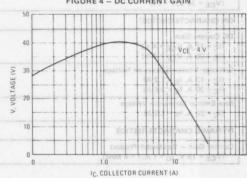


FIGURE 5 – RESISTIVE SWITCHING PERFORMANCE

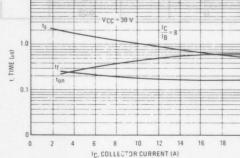
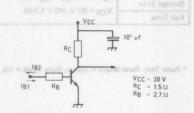


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT



RC - RB: Non inductive resistances



## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high current, high power applications.

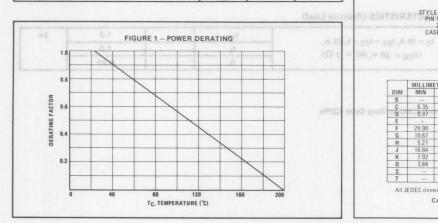
- High D.C. current gain:
   HFE min.: 15 at Ic = 10 A
  - Very fast switching times: Τ<sub>F</sub> max. = 0.25 μs at Ic = 15 A

#### MAXIMUM RATINGS

Adc	Rating	0.1	Symbol	Value	Unit
Collector-Em	itter Voltage	0.1	VCEO(sus)	125	Vdc
Collector-Bas	e Voltage	A	VCBO	160	Vdc
Emitter-Base	Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -2.5 V)		=-2.5 V)	VCEX	160	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )			VCER	150	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)			IC ICM	20 28	Adc Apk
Base-Current continuous		I <sub>B</sub>	4	Adc	
Total Power Dissipation @ T <sub>C</sub> = 25 °C		PD	120	Watts	
Operating and Temperatu	Storage Junction re Range		T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

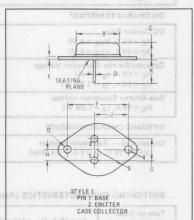
Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.46	°C/W



## 20 AMPERES NPN SILICON POWER METAL TRANSISTOR

125 VOLTS



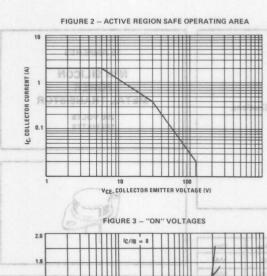


	MILLIM	ETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
В	-	22.23	-	0.875	
C	6.35	11.43	0.250	0.450	
D	0.97	1.09	0.038	0.043	
E	-	3.43		0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	7.92	-	0.312	-	
0	3.84	4.09	0.151	0.161	
S	-	13.34	-	0.525	
T	-	4.78	-	0.188	

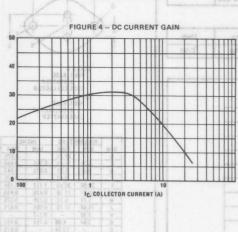
CASE 1-03

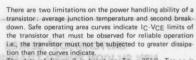
	Characteristic			Symbol	Min.	Max.	Unit
OFF CHARACTER			RO	TRANSIST	N POWER	NEW PUTICO	
Collector-Emitter S	sustaining Voltage B = 0, L = 25 mH)			VCEO(sus)	125	sare daid soft bear	Vdc
(VCE =160 V.	urrent at Reverse Biais: VBE = -1.5 V) VBE = -1.5 V, TC = 125°C)			CEX		1.0 nien me 5.0, 0,0	mAd
Collector-Emitter ( (V <sub>CE</sub> = 100 V)	Cutoff Current			ICEO	= 10 A	2E min.: 15 at lc 0.1	mAd
Emitter-Base Rever	se Voltage			VEBO	es: A at Z ol s	fast switching times, = 0.25 us a	V Valv
Emitter-Cutoff Cur (V <sub>EB</sub> = 5 V)	rent			<sup>1</sup> EBO		1.0	mAd
SECOND BREAKE	OOWN					RATINGS	MUMIXA
Second Breakdown (V <sub>CE</sub> = 30 V,	Collector Current with base t = 1 s)	ZHILD	80/8V	IS/b	4.0	Rating	Add
(V <sub>CE</sub> = 50 V,		Vde	116	VCEO(sus)	1.0	ter Voltage	lector-E nit
ON CHARACTER	ISTICS <sup>1</sup>	sbV sbV		ORDV		esarto)	/ neeS-restric
OC Current Gain (I <sub>C</sub> = 10 A, V <sub>C</sub> ) (I <sub>C</sub> = 15 A, V <sub>C</sub> )		Vac	001	hEE <sub>O</sub> V	15 8 001	= 38V) sperioV reti 45 = 38 A) specioV reti	-
Collector-Emitter S		sbA	OS.	VCE(sat)		arounimos — ma	Vdc
$(I_C = 10 A, I_B = I_C = 15 A, I_B = I_C = 15 A, I_B = I_C = 15 A$		Apk	86	l cm	(\$611)	1.2 1.6 unimo	о патано-в
Base-Emitter Satur		Watts	611	V <sub>BE(sat)</sub>	5"	S = gT (a) noitsqtrai 2.0	Vdc
DYNAMIC CHAR	ACTERISTICS	10	65 tu 201			в Язлея	nuteragma <sup>†</sup>
Current Gain — Bai (VCE = 15 V, I	ndwidth Product C = 1 A, f = 4 MHz)			f <sub>T</sub>	8.0	CHARACTERIST	MHz
12		M/O,	1.46	31.0	995	tance, Junction to C	telas Filamna
SWITCHING CH	ARACTERISTICS (Resis	stive Load)					
Turn on Time	9-33A2		T	ton	51394KH _ F 2	1.2	μs
Storage Time	$I_C = 15 \text{ A}, I_{B1} = I_{B2} = 1.88$ $(V_{CC} = 30 \text{ V, RC} = 2)$			t <sub>s</sub>		1.0	
Fall Time	1,400 = 22 1,110			tf		0.25	
	ANT LINETE.					411	
<sup>1</sup> Pulse Test: Pulse	Width ≤300 μs, Duty Cycle	<b>≤</b> 2º/o.					
	11 Usuf 2 2 Usa H						OERA DE





€ 1.2 VOLTAGE VCE IC. COLLECTOR CURRENT (A) FIGURE 4 - DC CURRENT GAIN





tion than the curves indicate.

The data of figure 2 is based on Tc = 25°C; TJ(pk) is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE

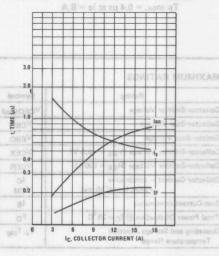
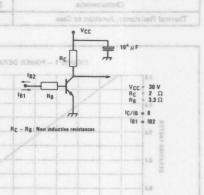


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT





## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high current, high power applications.

• Very fast switching times: Take A = 8 A TF max. = 0.4 μs at Ic = 8 A

#### 15 AMPERES

NPN SILICON POWER METAL TRANSISTOR

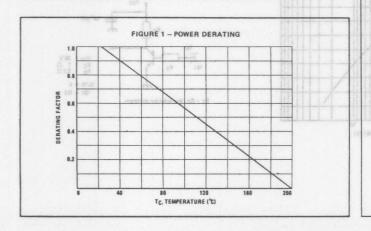
> 200 VOLTS 120 WATTS

#### MAXIMUM RATINGS

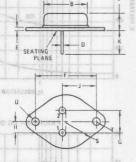
Rating	Symbol	Value	Unit		
Collector-Emitter Voltage	VCEO(sus)	200	Vdc		
Collector-Base Voltage	VCBO	250	Vdc		
Emitter-Base Voltage	VEBO	7	Vdc		
Collector-Emitter Voltage (VBE = -2.5 V)	VCEX	250	Vdc		
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	240	Vdc		
Collector-Current — continuous — peak (pw ≤ 10 ms)	I <sub>C</sub>	15 20	Adc Apk		
Base-Current continuous	IB	3	Adc		
Total Power Dissipation @T <sub>C</sub> = 25 °C	PD	120	Watt		
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C		

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.46	°C/W







STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR
STYLE 2:
PIN 1. BASE
2. COLLECTOR
CASE-EMITTER

	MILLIM	ETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
В	1411	22.23	-	0.875	
C	6.35	11.43	0.250	0.450	
D	0.97	1.09	0.038	0.043	
E		3.43	- Eman	0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.21	5.72	0.205	0.225	
J	16.64	17.15	0.655	0.675	
K	7.92	-	0.312		
a	3.84	4.09	0.151	0.161	
S	-	13.34	-	0.525	
T	-	4.78	-	0.188	

CASE 1-03 (TO-3)

to similarly of state to Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS1				
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	V <sub>CEO(sus)</sub>	200		Vdc
Collector Cutoff Current at Reverse Blais: $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 250 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 125^{\circ}\text{C})$	CEX		1.0 5.0	mAdd
Collector-Emitter Cutoff Current (VCE = 160 V)	CEO		1.0	mAde
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (V <sub>EB</sub> = 5 V)	¹EBO (₩)	ADP SLATION VOLTAGE	81 807381463 1.0	mAd
SECOND BREAKDOWN				
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 30 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 135 \text{ V}, t = 1 \text{ s}$ )	Is/b	4.0 0.15	- 8/2	Ado
ON CHARACTERISTICS <sup>1</sup>				
DC Current Gain (I <sub>C</sub> = 5 A, V <sub>CE</sub> = 4 V) (I <sub>C</sub> = 8 A, V <sub>CE</sub> = 4 V)	hFE	15 8	45	2
Collector-Emitter Saturation Voltage (I <sub>C</sub> = $5$ A, I <sub>B</sub> = $0.5$ A) (I <sub>C</sub> = $8$ A, I <sub>B</sub> = $1$ A)	VCE(sat)		1.2 1.6	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 8 A, I <sub>B</sub> = 1 A)	VBE(sat)		2.0	Vdo
DYNAMIC CHARACTERISTICS	, martir	01 (1 T T		
Current Gain — Bandwidth Product (V <sub>CE</sub> = 15 V, I <sub>C</sub> = 1 A, f = 4 MHz)	fT	8.0	283 Ho Ti	MHz

#### SWITCHING CHARACTERISTICS (Resistive Load)

FIGURE & - SWITCHING TIMES TEST CIRCUIT

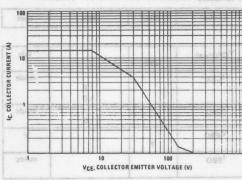
Turn on Time	I <sub>C</sub> = 8 A, I <sub>B1</sub> = I <sub>B2</sub> = 1 A, (V <sub>CC</sub> = 150 V, RC = 18.75 $\Omega$ )	ton	- 20 HILL 10	0.6	μз
Storage Time		ts		1.5	
Fall Time		ty	111/21 17	0.4	60

<sup>1</sup> Pulse Test: Pulse Width  $\leq$ 300  $\mu$ s, Duty Cycle  $\leq$ 2%.

3

IN COLLECTION CHRISTINY IN

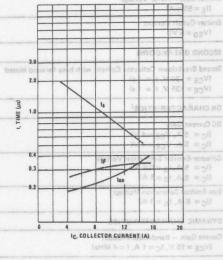




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on  $T_C=25^{\circ}C$ ;  $TJ_{\{pk\}}$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations, At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

#### FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE





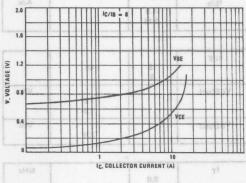
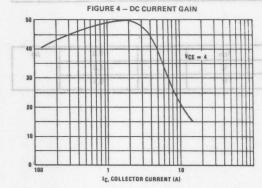
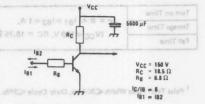


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT





SWITCHING CHARACTERISTICS (Resigive Load)

RC - Rg: Non inductive resistances



## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high current, high power applications.

- High DC current gain:
   HFE min. = 15 at Ic = 8 A
- Very fast switching times:
   TF max. = 0.25 μs at Ic = 12 A

# 18 AMPERES NPN SILICON POWER METAL TRANSISTOR 160 VOLTS (Val 120 WATTS

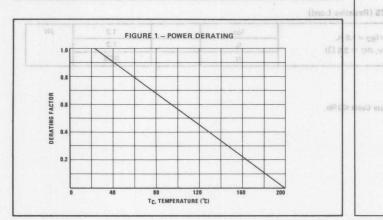


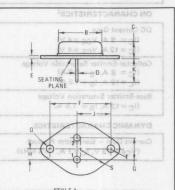
#### **MAXIMUM RATINGS**

Rating		Symbol	Value	Unit
Collector-Emitter Voltage		VCEO(sus)	160	Vdc
Collector-Base Voltage		VCBO	220	Vdc
Emitter-Base Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -2.5 V)		VCEX	220	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )		VCER	200	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)		I <sub>C</sub>	18 25	Adc Apk
Base-Current continuous		IB	-3.6	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C		PD	120	Watts
Operating and Storage Junction Temperature Range		T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.46	°C/W



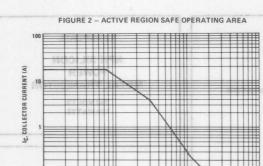


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR
STYLE 2:
PIN 1: BASE
2: COLLECTOR
CASE-EMITTER

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
В	-	22.23	-	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	-	0.312	
0	3.84	4.09	0.151	0.161
S	-	13.34	-	0.525
T	-	4.78	-	0.188

CASE 1-03 (TO-3)

2393 MA & Characteristic			Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS1		NO	TRANSIST	POWER	NHV SILICON	
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	- sanit	V	CEO(sus)	160	norm this his world	Vdc
Collector Cutoff Current at Reverse Biais: $(V_{CE} = 220 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 220 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 12 \text{ V})$	!5°C)		CEX		1.0 5.0	mAdc
Collector-Emitter Cutoff Current (VCE = 130 V)			CEO	A 8 =	FE min 0.1 15 at le	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)			VEBO	7 :8	fast switching time	TAV V
Emitter-Cutoff Current (VEB = 5 V)			IEBO	H 21 - 21	1.0	mAdc
SECOND BREAKDOWN					RATINGS	NUNDKA
Second Breakdown Collector Current with	base forward biased	suis V	Is/b	4	pelteR	Adc
(V <sub>CE</sub> = 30 V, t = 1 s) (V <sub>CE</sub> = 100 V, t = 1 s)	Vds	160	VCEO(sus)	0.27	egatioV rest	-3-rospetto
ON CHARACTERISTICS1	7 209	220	V690		Voltage	esti totsello
DC Current Gain $(I_C = 8 \text{ A, V}_{CE} = 4 \text{ V})$ $(I_C = 12 \text{ A, V}_{CE} = 4 \text{ V})$	Vdc Vdc	220	hFE 30V	15	= ggV) sustleV vari 45  = ag (4) spatieV vari	m5-resolte
Collector-Emitter Saturation Voltage	588	83	VCE(sat)	TO STATE OF THE PARTY OF	ent – continuous	Vdc
(I <sub>C</sub> = 8 A, I <sub>B</sub> = 0.8 A) (I <sub>C</sub> = 12 A, I <sub>B</sub> = 1.5 A)	Agk Ade	35	lcM lg	(bir	1.2	ZoeruÖ-ssa
Base-Emitter Saturation Voltage (I <sub>C</sub> = 12 A, I <sub>B</sub> = 1.5 A)	erzayy no	120	VBE(sat)		2.0 = 2.6	Vdc
DYNAMIC CHARACTERISTICS	100	-65 to 20	-1		u Punga	Теттретети
Current Gain – Bandwidth Product $(V_{CE} = 15 \text{ V}, I_{C} = 1 \text{ A}, f = 4 \text{ MHz})$			f <sub>T</sub>	8.0	CHARACTERIST	MHz
	MV3 <sub>o</sub>	1,48	1 0,0 1		tanca, Junction to Cas	harmal Rosis
SWITCHING CHARACTERISTICS (	Resistive Load)					
Turn on Time	o = 1.5 A.		ton	Rawos - r	1.2	μs
Storage Time (Vcc = 30 V, F			ts		1.2	10.7
Fall Time RETT RESEAS			tf		0.25	
XAN MIN MAK TING SAN MIN MIG						1,0
<sup>1</sup> Pulse Test: Pulse Width $\leqslant$ 300 $\mu$ s, Duty Cycle $\leqslant$ 2%.						N.O. 50
\$ 29.90 0.420 172 1797 1797 1797 1797 1797 1797 1797						22
K 9 92 - 0 312 - 0 515 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0						2.0

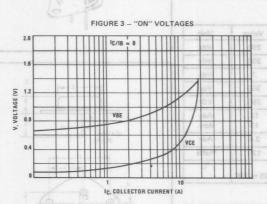


10

FIGURE 5 – RESISTIVE SWITCHING PERFORMANCE

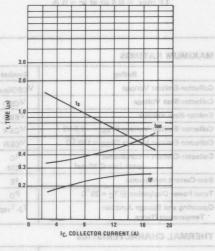
imposed by second breakdown. (See AN415A)

tion than the curves indicate.



100

VCE, COLLECTOR EMITTER VOLTAGE (V)

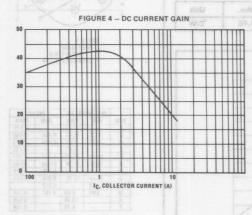


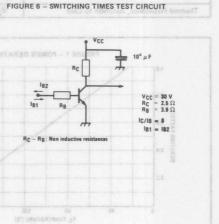
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-

down. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipa-

The data of figure 2 is based on  $T_C=25^\circ C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations.

At high case temperatures, thermal limitations will reduce the power that can handled to'values less than the limitations







## SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

- . . . designed for high speed, high voltage, high power applications.
- Low VCE(sat), VCE(sat) max. = 1.2 V at Ic = 4 A
- Very fast switching times:

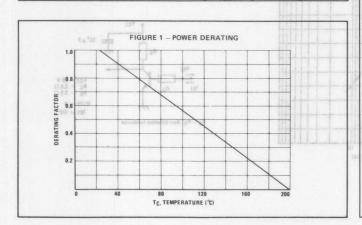
  Τρ max. = 0.4 μs at Ic = 6 A

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	250	Vdc
Collector-Base Voltage	VCBO	300	Vdc
Emitter-Base Voltage	VEBO	7	Vdc
Collector-Emitter Voltage (VBE = -2.5 V)	VCEX	300	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 100 $\Omega$ )	VCER	290	Vdc
Collector-Current — continuous — peak (pw ≤ 10 ms)	V) V <sub>CEX</sub> 300		Adc Apk
Base-Current continuous	IB	2.4	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 °C	PD	120	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit	
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.46	°C/W	

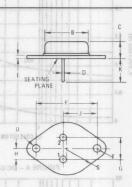


#### 12 AMPERES

NPN SILICON POWER METAL TRANSISTOR

> 250 VOLTS 120 WATTS





STYLE 1: PIN 1. BASE 2. EMITTER CASE-COLLECTOR

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
В		22.23		0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	10-	3.43	1-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	-	0.312	2-
0	3.84	4.09	0.151	0.161
S		13.34		0.525
T	-	4.78	-	0.188

CASE 1-03
(TO-3)

west d broose the sturgue Characteristic two contened	Symbol	Min.	Min. Max.	
OFF CHARACTERISTICS <sup>1</sup> and from high total and				
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	VCEO(sus)	250		Vdc
Collector Cutoff Current at Reverse Biais: (VCE = 300 V, VBE = -1.5 V) (VCE = 300 V, VBE = -1.5 V, TC = 125°C)	ICEX		1.0 5.0	mAd
Collector-Emitter Cutoff Current (V <sub>CE</sub> = 200 V)	CEO	MILI		
Emitter-Base Reverse Voltage (IE = 50 mA)	VEBO	7		V
Emitter-Cutoff Current (VEB = 5 V)	IEBO		1.0	mAd
SECOND BREAKDOWN	(V) 3DAY I	CYON EINSTERVO	32193 53V	
Second Breakdown Collector Current with base forward biased ( $V_{CE} = 30 \text{ V}, t = 1 \text{ s}$ ) ( $V_{CE} = 135 \text{ V}, t = 1 \text{ s}$ )	0.15		ENGURE TO THE WAR	Add
ON CHARACTERISTICS <sup>1</sup>				
DC Current Gain (IC = 4 A, VCE = 4 V) (IC = 6 A, VCE = 4 V)	hFE	15 8	45	11 3
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4 A, I <sub>B</sub> = 0.4 A) (I <sub>C</sub> = 6 A, I <sub>B</sub> = 0.75 A)	VCE(sat)	000	1.2 1.6	Vdd
Base-Emitter Saturation Voltage (IC = 6 A, IB = 0.75 A)	VBE(sat)		2.0	Vdo
DYNAMIC CHARACTERISTICS		111111111111111111111111111111111111111	101	

Current Gain — Bandwidth Product (VCE = 15 V, IC = 1 A, f = 4 MHz)

Turn on Time	1276 0 110.75 0	ton	0.6	μs
Storage Time	$I_C = 6 \text{ A}, I_{B1} = I_{B2} = 0.75 \text{ A},$ $(V_{CC} = 150 \text{ V}, \text{RC} = 25 \Omega)$	t <sub>s</sub>	2.0	
Fall Time	(VCC = 150 V, AC - 25 32)	tf	0.4	1

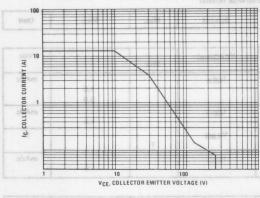
8.0

3

MHz

<sup>&</sup>lt;sup>1</sup> Pulse Test: Pulse Width  $\leq$ 300  $\mu$ s, Duty Cycle  $\leq$ 2%.

FIGURE 2 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on T<sub>C</sub> × 25 C; T<sub>J</sub>(p<sub>K</sub>) is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE

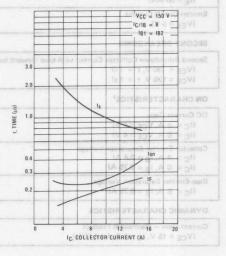


FIGURE 3 - "ON" VOLTAGES

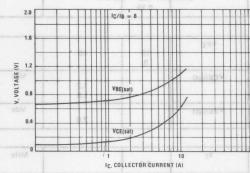


FIGURE 4 - DC CURRENT GAIN

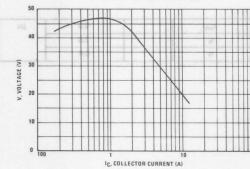
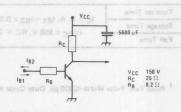


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT



R<sub>C</sub> - R<sub>B</sub>: Non inductive resistances



#### SWITCHMODE SERIES NPN SILICON POWER TRANSISTOR

... designed for high speed, high voltage, high power applications.

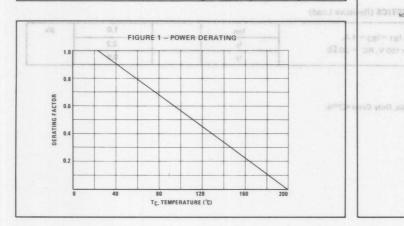
- VCE(sat) max. = 1.6 V at Ic = 6 A
- Very fast switching times: TF max. =  $0.90 \mu s$  at Ic = 5 A

#### **MAXIMUM RATINGS**

Rating	0.8	Symbol	Value	Unit
Collector-Emitter Voltage	0.15	VCEO(sus)	325	Vdc
Collector-Base Voltage		VCBO	400	Vdc
Emitter-Base Voltage		VEBO	7	Vdc
Collector-Emitter Voltage (VBE :	=-2.5 V)	VCEX	400	Vdc
Collector-Emitter Voltage (RBE	= 100 Ω)	VCER	360	Vdc
Collector-Current — continuous — peak (pw ≤	10 ms)	IC ICM	10 12	Adc Apk
Base-Current continuous	1	IB	2	Adc
Total Power Dissipation @ T <sub>C</sub> = 2	25°C	PD	120	Watts
Operating and Storage Junction Temperature Range		T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit	
Thermal Resistance, Junction to Case	θ <sub>JC</sub>	1.46	°C/W	

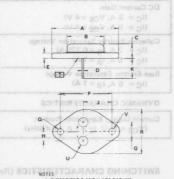


#### 10 AMPERES

#### NPN SILICON POWER METAL TRANSISTOR

325 VOLTS 120 WATTS





- NUTES

  1 DIMENSIONS O AND VARE DATUMS
  2 T IS SEATING PLANE AND DATUM
  3 POSITIONAL TOLERANCE FOR MOUNTING HOLE O
- → 13 (0 005) ⊙ T V ⊙ FOR LEADS

  | • 13 (0 005) • T | V • 0 • 0 • 0

  4 DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

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CASE 1-05 TO-3

	/T 0500 1 1 1 1 1 1
ELECTRICAL CHARACTERISTICS	$(10 = 25^{\circ}C)$ unless otherwise noted)

23939MA O'Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS <sup>1</sup>	RANSISTOR	T ABWO9 I	NPN SILICON	
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 200 mA, I <sub>B</sub> = 0, L = 25 mH)	VCEO(sus)	325		Vdc
Collector Cutoff Current at Reverse Biais: $(V_{CE} = 400 \text{ V}, V_{BE} = -1.5 \text{ V})$ $(V_{CE} = 400 \text{ V}, V_{BE} = -1.5 \text{ V}, T_{C} = 125^{\circ}\text{C})$	ICEX	o ingli sona	1.0 5.0	mAdc
Collector-Emitter Cutoff Current (VCE = 260 V)	CEO		1.0	mAdc
Emitter-Base Reverse Voltage (I <sub>E</sub> = 50 mA)	VEBO	Ady of	F max. = 0.90 µs a	V
Emitter-Cutoff Current (VEB = 5 V)	IEBO		1.0	mAdo

#### SECOND BREAKDOWN

Second Breakdown Collector Current with base forward biased (VCF = 30 V, t = 1 s)	IS/b	4.0	palieli	Adc
(V <sub>CE</sub> = 135 V, t = 1 s)	VOEO(aus) 325	0.15	tter Voltage	n3-rotoello0

#### ON CHARACTERISTICS1

DC Current Gain (IC = 3 A, VCF = 4 V)	Vde	400	hFE	15	= 2aV) 60 HoV mini	nB-rorselle:
(IC = 5 A, VCE = 4 V)	Vac	360	VCER	8200	itter Voltage (Rgg =	n 3-rotosileO
Collector-Emitter Saturation Voltage (IC = 3 A, IB = 0.375 A)	Ade Apk	0/ 2/	VCE(sat)	(em	sucuniznoa — zner 0 t ≥ wa) 1:0;q — 1.6	Vdc IIo2
(I <sub>C</sub> = 5 A, I <sub>B</sub> = 1 A)  Base-Emitter Saturation Voltage (I <sub>C</sub> = 5 A, I <sub>B</sub> = 1 A)	Ade Wate	120	V <sub>BE(sat)</sub>	Ď,	To an interest of the 20	Vdc

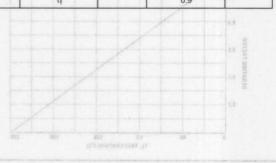
#### DYNAMIC CHARACTERISTICS 000 or 80-

Current Gain - Bandwidth Product	fT	23	CHARACTERIST	MHz
$(V_{CE} = 15 \text{ V}, I_{C} = 1 \text{ A}, f = 4 \text{ MHz})$		8.0		

#### SWITCHING CHARACTERISTICS (Resistive Load)

Turn on Time	PRINCIPAL CONTRACTOR OF THE PRINCIPAL CONTRACTOR OF T	ton	1.0	μs
Storage Time	$I_C = 5 \text{ A}, I_{B1} = I_{B2} = 1 \text{ A},$ $(V_{CC} = 150 \text{ V}, \text{RC} = 30 \Omega)$	t <sub>s</sub>	2.2	
Fall Time	(VCC = 150 V, AC = 30 32)	tf	0.9	2.1

 $<sup>^{1}</sup>$  Pulse Test: Pulse Width  $\leqslant$ 300  $\mu$ s, Duty Cycle  $\leqslant$ 2%.



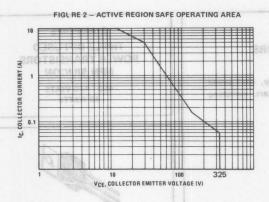
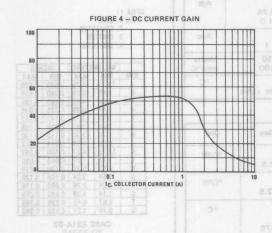


FIGURE 3 - "ON" VOLTAGES 2.0 IC/IB = 5 1.6 1.2 VOLTAGE (V) 0.8 VCE(sat) IC, COLLECTOR CURRENT (A)



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of figure 2 is based on  $T_C = 25^{\circ}C$ ,  $T_J(p_k)$  is variable depending on power level. Second breakdown limitations do not derate the same as thermal limitations. At high case temperatures, thermal limitations will reduce the power that can handled to values less than the limitations imposed by second breakdown. (See AN415A)

FIGURE 5 - RESISTIVE SWITCHING PERFORMANCE

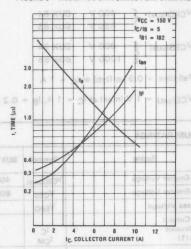
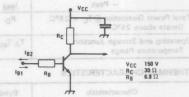


FIGURE 6 - SWITCHING TIMES TEST CIRCUIT



RC - RB: Non inductive resistances



**BUX43** 

## SWITCHMODE NPN SILICON POWER TRANSISTORS

The BUX 84/85 are designed for high voltage, high speed power switching applications like converters, inverters, switching regulators, motor control systems.

#### SPECIFICATIONS FEATURES:

VCEO(sus)
 400 V BUX 84
 450 V BUX 85

• VCES(sus) { 800 V BUX 84 1000 V BUX 85

• Fall time = 0.3 us (typ) at IC = 1 A

V<sub>CE(sat)</sub> = 1 V (max) at I<sub>C</sub> = 1 A, I<sub>B</sub> = 0.2 A

#### MAXIMUM RATINGS

Rating	Symbol	BUX 84	BUX 85	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCES	800	1000	Vdc
Emitter Base Voltage	VEBO		5	Vdc
Collector Current  - Continuous  - Peak(1)	I <sub>C</sub> M		2	Adc
Base Current  - Continuous  - Peak (1) 2000 Test 23MIX 000MSTW2	I <sub>B</sub>	-	75 .0	Adc
Reverse Base Current: - Peak	IBM		1	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		00	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 65 t	0 +150	°C

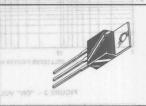
#### THERMAL CHARACTERISTICS

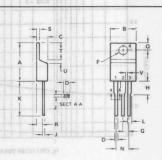
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ROJC	2.5	°C/W
Thermal Resistance, Junction to Ambien:	ROJA	62.5	°C/W
Maximum Lead Temperature for Soldering Purpose: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test. Pulse Width = 5 ms, Duty Cycle ≤ 10%.

## 2 AMPERES TRIPLE DIFFUSED POWER TRANSISTORS NPN SILICON

400 - 450 VOLTS 50 WATTS





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
- 11	0.76	1 27	0.030	0.050

CASE 221A-02 TO 220AB

Characteristic	A8+-1727	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)		90				
Collector-Emitter Sustaining Voltage (IC = 100 mAdc, (L = 25 mH) See fig. 1	BUX 84 BUX 85	VCEO(sus)	400 450	-	-	Vdc
Collector Cutoff Current (VCES = Rated Value) (VCES = Rated Value, TC = 125 ° C)	7-4	ICES	E Transco	-	0.2 1.5	mAdo
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0)	100	IEBO	_	_	1	mAdd

PIGURE 1 - TEST CIRCUIT FOR VOSO sunt

#### ON CHARACTERISTICS (1)

DC Current Gain (IC = 0.1 Adc, VCE = 5 V)	hFE	30	50	-	-
Collector-Emitter Saturation Voltage (IC = 0.3 Adc, IB = 30 mAdc) (IC = 1 Adc, IB = 200 mAdc)	VCE(sat)		-	0.8	Vdc
Base-Emitter Saturation Voltage (IC = 1 Adc, IB = 0.2 Adc)	VBE(sat)	se -	-	1.1	Vdc

#### DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product	fT	01 4			MHz
(IC = 500 mAdc, VCE = 10 Vdc, f = 1 MHz)			7	-	

#### SWITCHING CHARACTERISTICS

Turn-on Time	VCC = 250 Vdc, IC = 1 A	ton	- 0.0457	0.3	0.5	μs
Storage Time	IB1 = 0.2 A, IB2 = 0.4 A	ts	-	2	3.5	μs
Fall Time	See fig. 2	tf	A -	0.3	-	μs
Fall Time	Same above cond. at TC = 95°C	tf	-	-	1.4	μs

(1) Pulse Test: PW = 300 µs, Duty Cycle ≤ 2%.

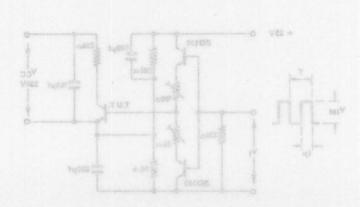
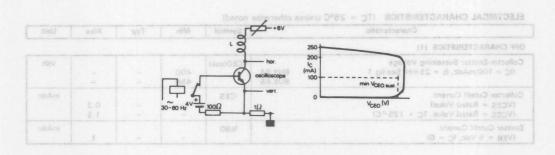
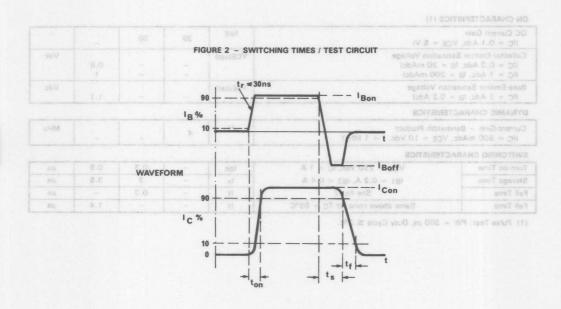
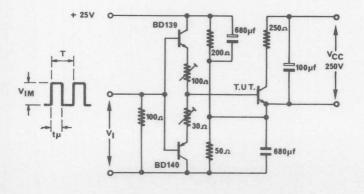


FIGURE 1 - TEST CIRCUIT FOR VCEO sust







D40C5

. . . designed for amplifier and driver applications where high gain is an essential requirement, low power lamp and relay drivers and power drivers for high-current applications such as voltage regulators.

- High DC Current Gain –
   h<sub>FE</sub> = 40,000 (Min) @ l<sub>C</sub> = 200 mAdc D40C2, 5
- Collector-Emitter Breakdown Voltage BVCEO = 40 Vdc (Min) @ IC = 10 mAdc — D40C4, 5
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.5 Vdc (Max) @ I<sub>C</sub> = 500 mAdc
- Duowatt Package —
   2 Watts Free Air Dissipation @ TA = 25°C

#### **MAXIMUM RATINGS**

Rating	Symbol	D40C1,2	D40C4,5	Unit
Collector-Emitter Voltage	VCEO	30	40	Vdc
Collector-Emitter Voltage	VCES	30	40	Vdc
Emitter-Base Voltage	VEBO	1	3	Vdc
Collector Current — Continuous Peak (1)	lc		.5 .0	Adc
Base Current — Continuous	IB	10	00	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C (2)	PD		67 3.3	Watts mW/O
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	6.25		Watts mW/ <sup>O</sup> (
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to	+150	°c
Solder Temperature, 1/16" from Case for 10 Seconds				°c

#### THERMAL CHARACTERISTICS

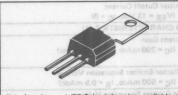
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	75	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	20	°C/W

(1) Pulse Width ≤ 25 ms, Duty Cycle ≤ 50%.

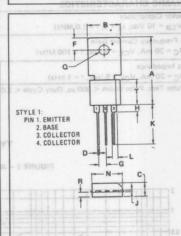
(2) The actual power dissipation capability of Duowatt transistors are 2 W @ T<sub>A</sub> = 25°C.

#### DUOWATT

DARLINGTON AMPLIFIER
TRANSISTORS



Tab forming and TO-5 lead forming evallable on special request.



FI	MILLIN	HETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F.	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
H	1.70	1.96	0.067	0.077	
J	0.48	0.66	0.019	0.026	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
0	3.56	3.81	0.140	0.150	
R	1.07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

TO-202AC CASE 306-04



ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					IF IF IT I
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 10 mAdc, V <sub>BE</sub> = 0)	D40C1, 2 D40C4, 5	BVCEO	30 40	NEW SILL AMPLIF	Vdc
Collector Cutoff Current (V <sub>CB</sub> = Rated V <sub>CES</sub> , I <sub>E</sub> = 0, T <sub>J</sub> = 150°C)	ei niso ripi	ICBO	and driver app	20 reitilgens vot be	μAdc
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CES</sub> , V <sub>BE</sub> = 0)	ind power	ICES DAY	qmal = woq v ications such	require.come, to	μAdc
Emitter Cutoff Current (VEB = 13 Vdc, IC = 0)		IEBO	-	100	nAdc
ON CHARACTERISTICS (1)		3 000000 16	A- 000	in Amital OOO Ob-	on right w
Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc)	D40C1, 4 D40C2, 5	hFE Ade - DAGCA,	10,000	60,000	
Collector-Emitter Saturation Voltage (IC = 500 mAdc, IB = 0.5 mAdc)		VCE(sat)	Review Volt	8 vest 1.5 notate	lo⊃ Vdc ⊚
Base-Emitter Saturation Voltage (IC = 500 mAdc, IB = 0.5 mAdc)		VBE(sat)	- T @ noise	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Collector Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)		C <sub>cb</sub>	-	10	pF

(I<sub>C</sub> = 20 mA,  $V_{CE}$  = 5 Vdc, f = 1 kHz) (1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%

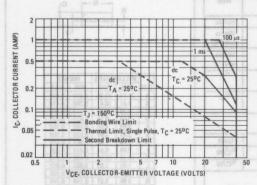
(IC = 20 mA, VCE = 5 Vdc, f = 100 MHz)

High Frequency Current Gain

Input Impedance

#### TYPICAL CHARACTERISTICS

#### FIGURE 1 - ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

1.0

50

Ohms

MAXIMUM RATINGS

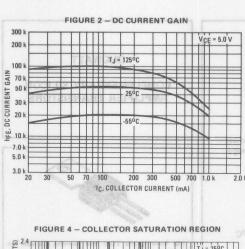
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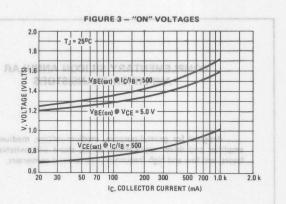
hie

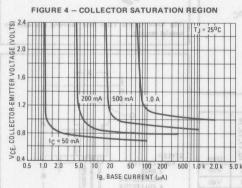
The data of Figure 1 is based on  $T_J(pk) = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leqslant 150^{\circ}C$ .  $T_J(pk)$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

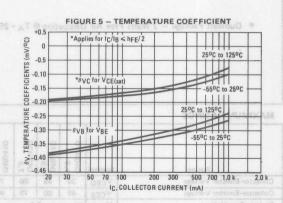


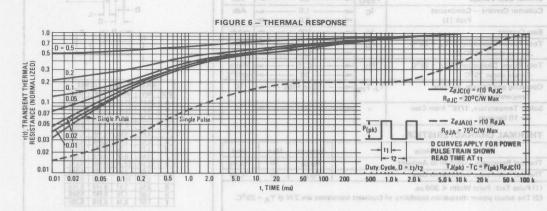














### COMPLEMENTARY SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

● Duowatt Package - 2 Watts Free Air Dissipation @ TA = 25°C

#### MAXIMUM RATINGS

III A A A A A A A A A A A A A A A A A A				133		
Rating	Symbol	D40/41D 1,2	D40/41D 4,5	D40/41D 7,8	D40/41D 10,11,13,14	Unit
Collector-Emitter Voltage	VCEO	30	45	60	75	Vdc
Collector-Emitter Voltage	VCES	45	60	75	90	Vdc
Emitter-Base Voltage	VEBO	-	5	.0 —	>	Vdc
Collector Current — Continuous Peak (1)	1c	1.0		Adc		
Base Current	IB	-	1	00 —	-	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C (2)	PD	4		.67— 3.3—		Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	4	-141-19	25 —		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	4	-55 to	+150		°C
Solder Temperature, 1/16" from Case for 10 Seconds	- 1	4	2	60 —	>	°С

#### THERMAL CHARACTERISTICS

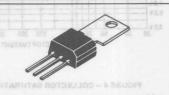
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta}JA$	75	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	20	oC/M

(1) Pulse Test: Pulse Width ≤ 300 µs.

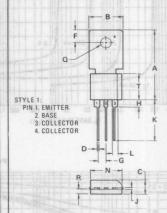
(2) The actual power dissipation capability of Duowatt transistors are 2 W @  $T_A$  = 25°C.

#### DUOWATT

#### COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS



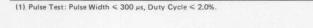
Tab forming and TO-5 lead forming available on special request.

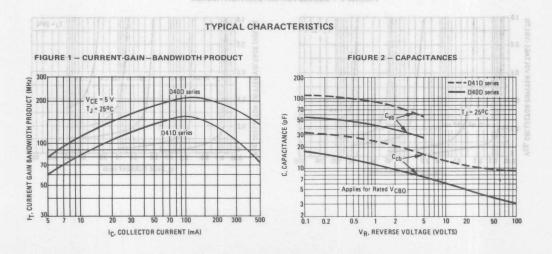


	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
Q	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

TO-202AC CASE 306-04

Characte	ristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				2088	TUT
Collector-Emitter Breakdown Voltage		BVCEO	THE T		Vdc
(I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)	D40D1,2/D41D1,2		30	50.7	
1111/12/1 1111/1 1 <sub>70</sub> 1 <sub>8</sub> .	D40D/D41D-4,5		45		
11101111111111111	D40D/D41D-7,8	111111111111111111111111111111111111111	60		
	D40D/D41D-10,11,13,14	In the second	75	VOI STONE	10
Collector Cutoff Current		ICES		100	nAdc
(VCE = Rated VCES)					
Emitter Cutoff Current		IEBO		100	nAdc
(VEB = 5.0 Vdc)		MILLER			
ON CHARACTERISTICS (1)	01 0.0 0.5 0.1	4.0.7 00ê 00S	907 98	04 01 03	0.3 8.1
DC Current Gain (Am) THERMUS ACTORS	100.36	hFE	(Am) (MBN8V	TE, COLLEGIOR C	-
(IC = 100 mAdc, VCE = 2.0 Vdc)	D40D/D41D-1,4,7,10,13		50	150	
	D40D/D41D-2,5,8,11,14		120	360	
		FIGURE 4 - "CA			
(IC = 1.0 Adc, VCE = 2.0 Vdc)	D40D1,4,5,7,8,10,11		10	-	
BUTTELL BUTTELL	D41D1,4,5,7,8,10,11	NUTTITI	10	TILL	
KINLI-LILLILLILLILLILLILLILLILLILLILLILLILL	D40D/D41D-2	MONTH I	20	DP81 - ET 1 1 1	
Collector-Emitter Saturation Voltage		VCE(sat)			Vdc
(IC = 500 mAdc, IB = 50 mAdc)	D40D/D41D-1,2,4,5	HILLIA		0.5	
	D40D,7,8,10,11,13,14			1.0	
	D41D7,8,10,11,13,14			1.0	1 20
Base-Emitter Saturation Voltage		V <sub>BE(sat)</sub>		1.5	Vdc
(I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc)					
DYNAMIC CHARACTERISTICS					100
Current Gain - Bandwidth Product		fT	75	375	MHz
(IC = 20 mA, VCE= 10 Vdc, f = 20	MHz)				2.0
Collector-Base Capacitance	M Buot e briefan	C <sub>cb</sub>	17 1 20 -	101 4 (m) 30 1 1 1	pF
(VCB = 20 Vdc, IE = 0, f = 1 MHz)	D40D series	CD		12	





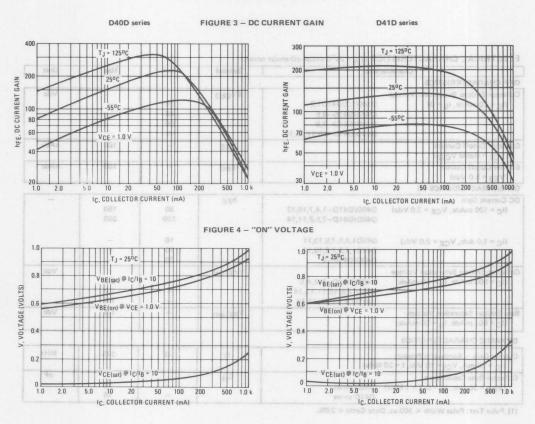
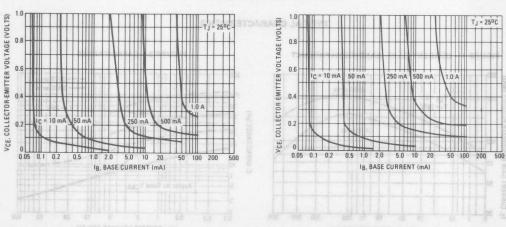


FIGURE 5 - COLLECTOR SATURATION REGION



MOTOROLA

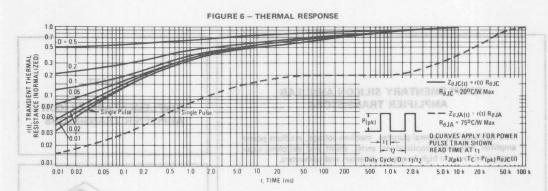
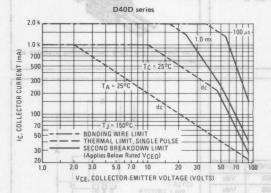
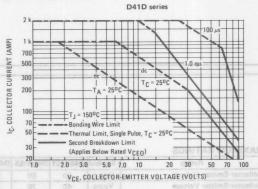


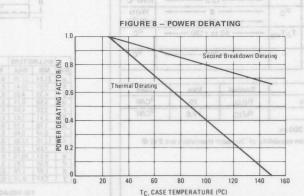
FIGURE 7 - ACTIVE-REGION SAFE-OPERATING AREA - STANKS - SONOS OF TENEDOS OF



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits\_of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.



The data of Figure 7 is based on  $T_{J(pk)}=150^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$  provided  $T_{J(pk)} \le 150^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



D40D, NPN, D41D, PNP

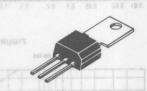
## COMPLEMENTARY SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, medium-voltage, medium power amplifier and driver applications; series, shunt and switching regulators, and low and high frequency inverters and converters.

● Duowatt Package - 2 Watts Free Air Dissipation @ TA = 25°C

#### DUOWATT

COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS



Tab forming and TO-5 lead forming available on special request.

MANUAL DATINGS

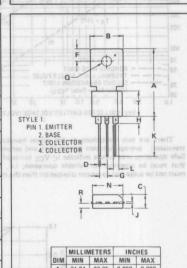
MAXIMUM RATINGS				E E	45
per ot as Rating as or o	Symbol	D40/41E1	D40/41E5	D40/41E7	Unit
Collector-Emitter Voltage	VCEO	30	60	80	Vdc
Collector-Emitter Voltage	VCES	40	70	90	Vdc
Emitter-Base Voltage	VEBO	turni il to co	5.0	-	Vdc
Collector Current - Continuous Peak (1)	IC	I Stranger	2 3	-01	Adc
Base Current	I <sub>B</sub>	from the	— 0.5 —	100	mAdc
Total Power Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$ (2)	PD	1.67			Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	- 01	8 64	HEURUT -	Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	1	55 to +15	0	°C
Solder Temperature, 1/16" from Case for 10 Seconds	- pr	- St. Hamilton	260	-	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	ROJA	75	°C/W
Thermal Resistance, Junction to Case	RθJC	15.6	oC\AA

NOTES 1. Pulse Test: Pulse Width ≤ 300 µs.

2. The actual power dissipation capability of Duowatt transistors are 2 W @  $T_{\mbox{\scriptsize A}}$  =  $25^{\mbox{\scriptsize O}}\mbox{\scriptsize C}.$ 



	MILLIN	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
H	1.70	1.96	0.067	0.077	
J	0.48	0.66	0.019	0.028	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
Q	3.56	3.81	0.140	0.150	
R	1.07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

TO-202AC CASE 306-04

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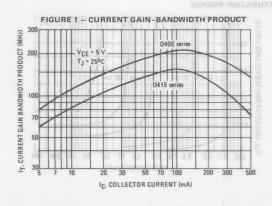
Characterist	ic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)	D40E1/D41E1 D40E5/D41E5 D40E7/D41E7	BVCEO	30 60 80		Vdc
Emitter Cutoff Current (VEB = 5.0 Vdc, IC = 0)	######################################	IEBO		100	nAdc
Collector Cutoff Current (VCE = Rated VCES)	05 - 3	ICES		100	nAdc
ON CHARACTERISTICS (1)	III I WATER OF	White			
DC Current Gain (I <sub>C</sub> = 100 mAdc, $V_{CE}$ = 2.0 Vdc) (I <sub>C</sub> = 1.0 Adc, $V_{CE}$ = 2.0 Vdc)	1.0 2.0 8.0 10 1.0 2.0 8.0 10 10, 00	hFE 40.7 003	50 08 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	05 — 01 05 — 01 1   1   1   1   1   1   1   1   1   1	2.0 5.0
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)		VCE(sat)	-	1.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)	POLTAGE	V <sub>BE</sub> (sat)	-	1.3	Vdc

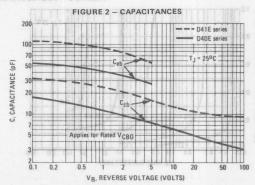
#### DYNAMIC CHARACTERISTICS

Current Gain —Bandwidth Product (IC = 20 mA, VCE = 10 Vdc, f = 20 MHz)	0 TS	fT	75	375	MHz
Collector-Base Capacitance	0		T. Ditt		
(V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1 MHz) D40E series D41E series		C <sub>cb</sub>	-	18	pF
D41E series	2		T	18	

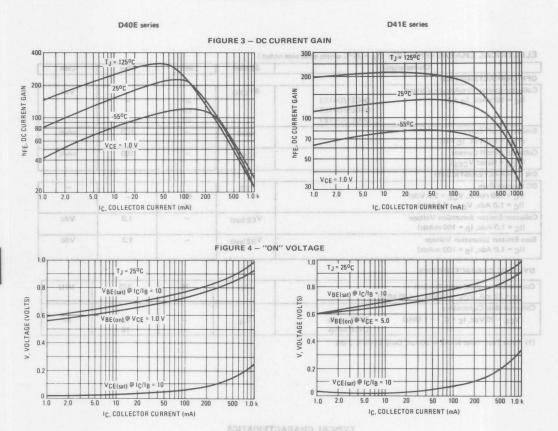
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

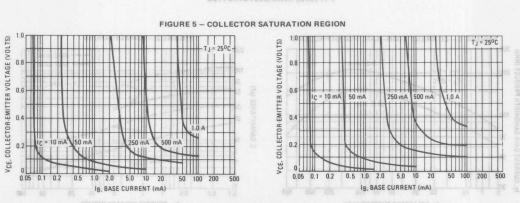
#### TYPICAL CHARACTERISTICS











MOTOROLA

#### TYPICAL CHARACTERISTICS (continued)

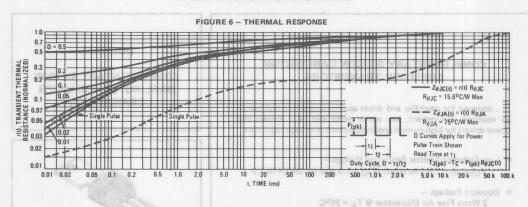
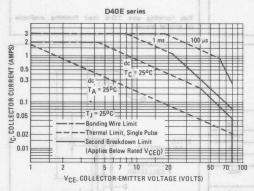
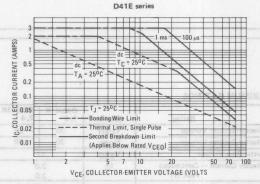


FIGURE 7 - ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.



The data of Figure 7 is based on  $T_{J(pk)}=150^{9}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{9}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

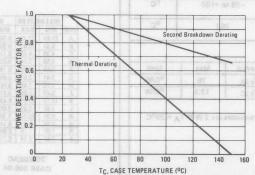


FIGURE 8 - POWER DERATING

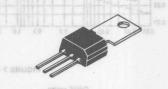
# COMPLEMENTARY SILICON DARLINGTON AMPLIFIER TRANSISTORS

... designed for amplifier and driver applications where high gain is an essential requirement, low power lamp and relay drivers and power drivers for high-current applications such as voltage regulators.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.5 Vdc (Max) @ I<sub>C</sub> = 1.5 Adc for D40,41K1,2
- Duowatt Package –
   2 Watts Free Air Dissipation @ T<sub>A</sub> = 25°C

### DUOWATT

COMPLEMENTARY SILICON DARLINGTON AMPLIFIER TRANSISTORS



Tab forming and TO-5 lead forming available on special request.

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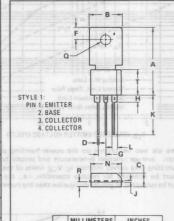
#### MAXIMUM RATINGS

Rating	Symbol	D40/41K 1,3	D40/41K 2,4	Unit
Collector-Emitter Voltage	VCEO	30	50	Vdc
Collector-Emitter Voltage	VCES	30	50	Vdc
Emitter-Base Voltage	VEBO	1:	3	Vdc
Collector Current — Continuous Peak (1)	IC	2.0 3.0		Adc
Base Current - Continuous	IB .	100		mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C (2)	PD	1.67		Watts mW/ <sup>o</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150		°C
Solder Temperature, 1/16" from Case for 10 Seconds	-	260		°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	75	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

- 1. Pulse Width ≤ 25 ms, Duty Cycle ≤ 50%.
- 2. The actual power dissipation capability of Duowatt transistors are 2 W @ TA = 25°C.



7	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

TO-202AC CASE 306-04

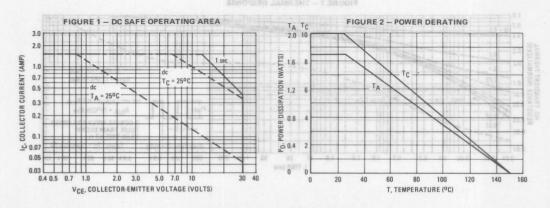
# TVPICAL CHARACTERISTICS (continued)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS		707			35,923 = 51,	
Collector-Emitter Breakdown Voltage (1) (IC = 10 mAdc)	D40,41K1,3 D40,41K2,4	100 E	BVCEO	30 50		Vdc
Collector Cutoff Current (V <sub>CB</sub> = Rated V <sub>CES</sub> , I <sub>E</sub> = 0, T <sub>J</sub> = 150°C	:)	A HE HERE	СВО		20	μAdc
Collector Cutoff Current (VCE = Rated VCES, VBE = 0)		3,4 8	ICES	U-T	0.5	μAdc
Emitter Cutoff Current (VEB = 13 Vdc, I <sub>C</sub> = 0)		707	EBO		100	nAdc
ON CHARACTERISTICS (1)		X 0.0				
DC Current Gain (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	All Devices D40,41K1,2 D40,41K3,4	28	whFE ad	10,000 1,000 1,000	70 189 209 10, CLUECTOR	ria <del>d</del> e i
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 3.0 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mA)	D40,41K1,2 D40,41K3,4	TAGES	VCE(sat)	Caiver M	1.5 AUDIT	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 3.0 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)	D40,41K1,2 D40,41K3,4	6.1	V <sub>BE</sub> (sat)	= 1	2.5 2.5	Vdc Vdc
DYNAMIC CHARACTERISTICS		- 81 69			ENS	
Collector Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	D40K series D41K series	1,1 M	C <sub>cb</sub>		10 25	pF
High Frequency Current Gain (IC = 20 mA, VCE = 5 Vdc, f = 100 MH	Hz)	NOT IT	Ihfel	1.0	0.8 = 93V © (na)38	

Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

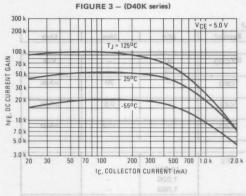
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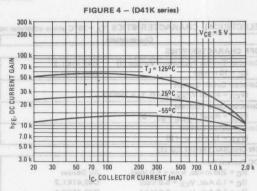
#### TYPICAL CHARACTERISTICS



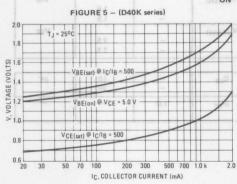
#### TYPICAL CHARACTERISTICS (continued)

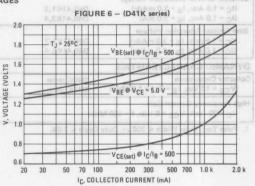




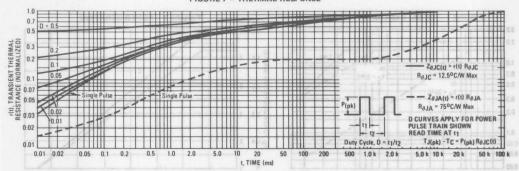


#### "ON" VOLTAGES



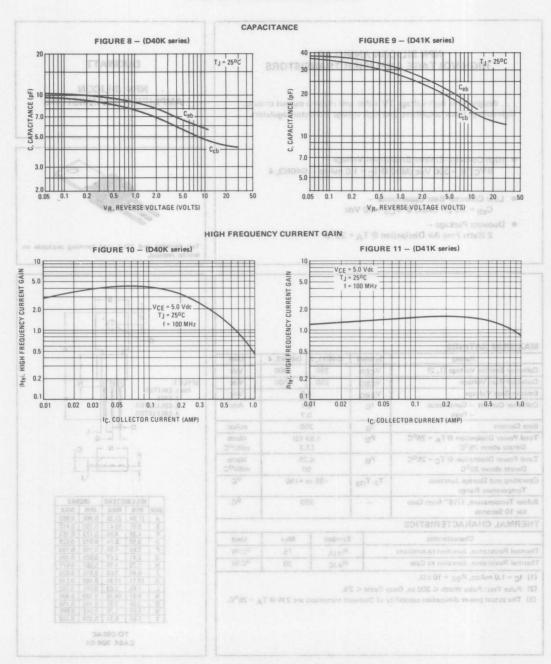


# FIGURE 7 - THERMAL RESPONSE





#### TYPICAL CHARACTERISTICS (continued)





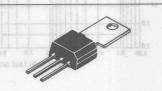
# NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage BVCER = 300 Vdc (Min) @ IC = 1.0 mAdc - D40N3, 4
- Low Collector-Base Capacitance C<sub>cb</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 20 Vdc
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C TMARRUS YSMASUDARA A

DUOWATT

NPN SILICON **AMPLIFIER TRANSISTORS** 



Tab forming and TO-5 lead forming available on special request.

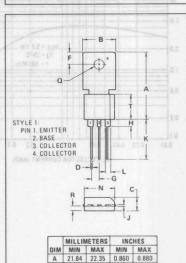
#### MAYIMIM PATINGS

MAXIMUM RATINGS				
Rating	Symbol	D40N1, 2	D40N3, 4	Unit
Collector-Emitter Voltage (1, 2)	VCER	250	300	Vdc
Collector-Base Voltage	VCBO	250	300	Vdc
Emitter-Base Voltage	VEBO	5	.0	Vdc
Collector Current — Continuous — Peak	IC .	0.1 0.7		M Adc
Base Current	IB	250		mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.67 (3) 13.3		Watts mW/OC
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	6.25 50		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150		°C
Solder Temperature, 1/16" from Case for 10 Seconds	-	260		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	75	°C/W	
Thermal Resistance, Junction to Case	Raic	20	°C/W	

- (1)  $I_C = 1.0 \text{ mAdc}$ ,  $R_{BE} = 10 \text{ k}\Omega$ .
- (2) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2%.
- (3) The actual power dissipation capability of Duowatt transistors are 2 W @ TA = 25°C.



		IF LEH2	HS INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	21.84	22.35	0.860	0.880	
В	9.91	10.41	0.390	0.410	
C	4.39	4.65	0.173	0.183	
D	0.58	0.74	0.023	0.029	
F	3.56	4.06	0.140	0.160	
G	2.41	2.67	0.095	0.105	
Н	1.70	1.96	0.067	0.077	
J	0.48	0.66	0.019	0.026	
K	12.19	12.95	0.480	0.510	
L	1.65	2.03	0.065	0.080	
N	9.91	10.16	0.390	0.400	
Q	3.56	3.81	0.140	0.150	
R	1.07	1.75	0.042	0.069	
T	7.87	9.14	0.310	0.360	

TO-202AC CASE 306-04

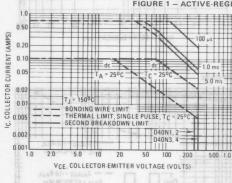
#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	)/A		MIAD TUDE	SURE 2 - DC CURI	PE
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0, R <sub>BE</sub> = 10 kΩ)	D40N1, 2 D40N3, 4	BVCER	250 300	27221 = 17	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 250 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 300 Vdc, I <sub>E</sub> = 0)	D40N1, 2 D40N3, 4	Ісво		10	μAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	unaav III s	IEBO	III-	10	μAdc
ON CHARACTERISTICS (1)	(em)36V	17.30			MARKET
DC Current Gain (I <sub>C</sub> = 4.0 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 20 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 40 mAdc, V <sub>CE</sub> = 10 Vdc)	D40N1,3 D40N2,4 D40N1,3 D40N2,4 D40N1,3 D40N2,4	hee	20 30 30 60 20	90 180	5.0
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (IC = 20 mAdc, VCE = 10 Vdc, f = 20 MHz)		fT	50	-	MHz
Collector-Base Capacitance (V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	All and analogo A"	C <sub>cb</sub>		3.0	PF

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

#### TYPICAL CHARACTERISTICS

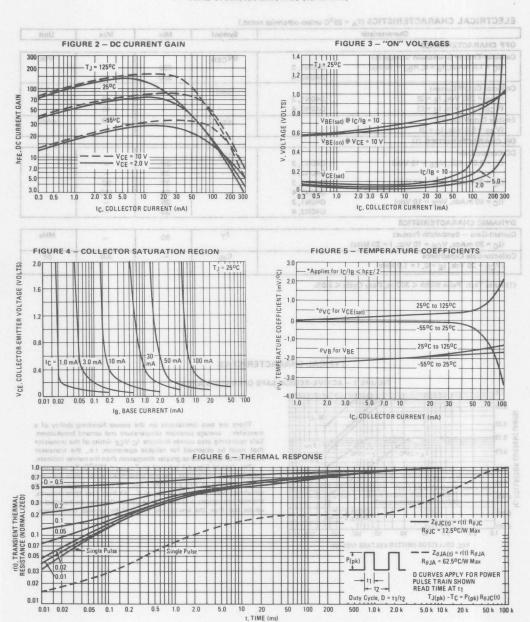
#### FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $TJ_{(pk)}=150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ_{(pk)} \leqslant 150^{\circ}C$ .  $TJ_{(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### TYPICAL CHARACTERISTICS (continued)



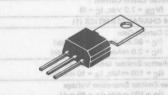


# NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

. . . designed for horizontal drive applications, high-voltage linear amplifiers, and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage -BVCEO = 225 Vdc (Min) @ IC = 1.0 mAdc - D40P5
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 Vdc (Max) @ IC = 100 mAdc
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C

DUOWATT NPN SILICON AMPLIFIER TRANSISTORS



Tab forming and TO-5 lead forming available on special request.

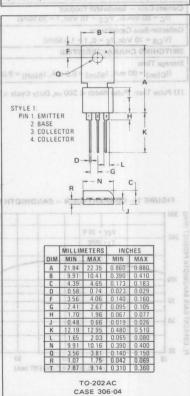
#### MAXIMUM RATINGS

			,	,	-
Rating	Symbol	D40P1	D40P3	D40P5	Unit
Collector-Emitter Voltage	VCEO	120	180	225	Vdc
Collector-Base Voltage	VCBO	200	250	300	Vdc
Emitter-Base Voltage	VEBO	-	— 7.0 <b>—</b>	-	Vdc
Collector Current - Continuous Peak (1)	¹c	-	0.5 1.0		Adc
Base Current	IB	4	—100 —	-	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD		- 1.67 (2) - 13.3 -		Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	-	6.25 50		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-55 to +15	0	°C
Solder Temperature, 1/16" from Case for 10 Seconds			260	•	°c

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	75	oC/M
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	20	°C/W

- (1) Pulse Test: Pulse Width ≤ 1.0 ms, Duty Cycle ≤ 50%.
- (2) The actual power dissipation capability of Duowatt transistors are 2 W @  $T_A$  = 25°C.



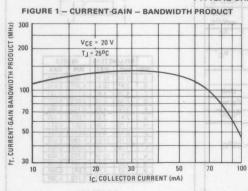
3-717

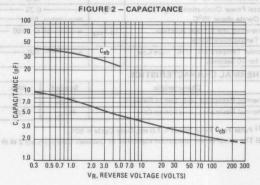
FLEOTRICAL	CHARACTERISTICS (=	0-		
ELECTRICAL	CHARACTERISTICS (TA	= 25°C unless	otnerwise	noted.)

Character	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	SA I	LIBERA DIAM	LISS MOLE	
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0) D40P1 D40P3 D40P5	BVCEO	120 180 225	VOLTAGE A	Vdc
Collector Cutoff Current (VCB = 200 Vdc, IE = 0) D40P1 (VCB = 250 Vdc, IE = 0) D40P3 (VCB = 300 Vdc, IE = 0) D40P5	Сво	transistor regul	10 10	μAdc
Emitter Cutoff Current (VEB = 7.0 Vdc, IC = 0)	ago de le Bol Am	0.1 = 51 @ (ni	0 = 22.01/dc (W	μAdc
ON CHARACTERISTICS (1)	- 00	stick doiteur	GOT-Emitter Sa	e Low Code
DC Current Gain (I <sub>C</sub> = 80 mAdc, V <sub>CE</sub> = 10 Vdc) (I <sub>C</sub> = 2.0 mAdc, V <sub>CE</sub> = 10 Vdc)	hream	40 20	(t) = 1.0 Vdc (f) - Vackage-	Blackett
Collector-Emitter Saturation Voltage (IC = 100 mAdc, IB = 10 mAdc)	VCE(sat)	E AT € noise	Free 0.1 Dissi	Vdc
Base-Emitter Saturation Voltage (IC = 100 mAdc, IB = 10 mA)	V <sub>BE</sub> (sat)	-	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I <sub>C</sub> = 80 mAdc, V <sub>CE</sub> = 10 Vdc, f = 20 MHz)	fT	50	<del>-</del>	MHz
Collector-Base Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>cb</sub>	-	6.0	pF
SWITCHING CHARACTERISTICS				
Storage Time (I <sub>C(on)</sub> = 80 mA, I <sub>B(on)</sub> = 8.0 mA, I <sub>B(off)</sub> = 8.0 mA)	ts	-	2.5	μs

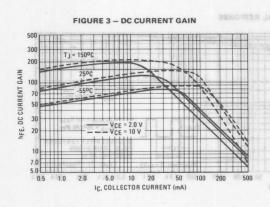
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

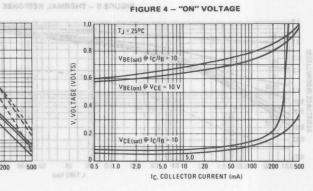
# TYPICAL CHARACTERISTICS

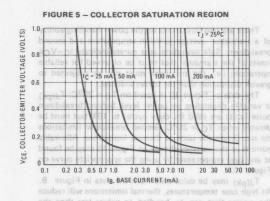


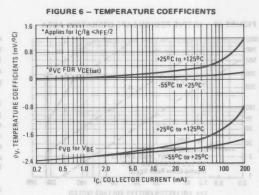


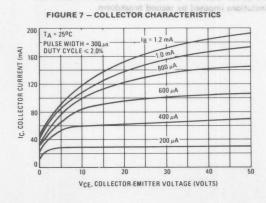
# TYPICAL CHARACTERISTICS (Continued)

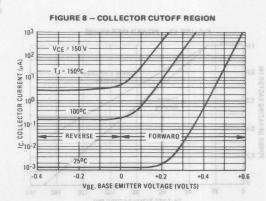






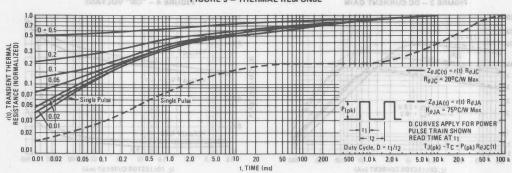






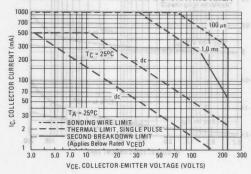
#### TYPICAL CHARACTERISTICS (Continued)

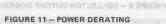
FIGURE 9 - THERMAL RESPONSE

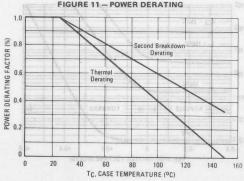


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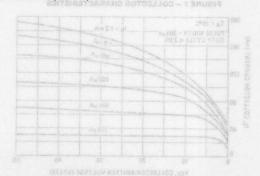


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

FIGURE 5 - COLLECTOR SATURATION REGION

The data of Figure 10 is based on  $T_C = 25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

TJ(pk) may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



### COMPLEMENTARY SILICON POWER TRANSISTORS

... for general purpose driver or medium power output stages in CW or switching applications.

- Low Collector-Emitter Saturation Voltage 0.5 V (Max)
- High ft for Good Frequency Response
- Low Leakage Current

# MAXIMUM RATINGS

Reg						
Rating	Symbol	1,2,	4,5,	7,8,	10,11, 12	Unit
Collector-Emitter Voltage	VCEO	30	45	60	80	Vdc
Collector-Emitter Voltage	VCES	40	55	70	90	Vdc
Emitter Base Voltage	VEB	5.0				Vdc
Collector Current — Continuous Peak (1)	lc	4.0			Adc	
Total Power Dissipation  @ T <sub>C</sub> = 25°C  @ T <sub>A</sub> = 25°C	Qa PD	30 1.67		anin	Watts W/°C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,	-55 to 150		4611	°C	

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	4.2	°C/W
Thermal Resistance, Junction to Ambient	R <sub>0</sub> JA	75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	— 2 Э <b>т</b> [ЦОРН	275	°C

(1) Pulse Width ≤ 6.0 ms, Duty Cycle ≤ 50%.

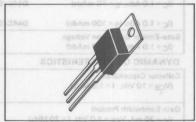
#### ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted)

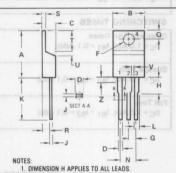
Characteristic		Symbol	Min	Max	Unit
DC Current Gain (V <sub>CE</sub> = 1.0 Vdc, I <sub>C</sub> = 0.2 Adc)	D44C3,6,9,12 D45C3,6,9,12 D45C2,5,8,11	hFE	40	120	
	D44C2,5,8,11		100	220	1
63C1.2.3 65C4.5.8			25		1
(V <sub>CE</sub> = 1.0 Vdc, I <sub>C</sub> = 1.0 Adc)	D44C3,6,9,12 D45C3,6,9,12 D44C2,5,8,11	0.5	20	0.8.0	0.3
(V <sub>CE</sub> = 1.0 Vdc, I <sub>C</sub> = 2.0 Adc)	D45C2,5,8,11		20	_	
	D44C1,4,7,10 D45C1,4,7,10		10	-	

# 4.0 AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

30-80 VOLTS V 0.8 = 83V)





- OTES:

  1. DIMENSION H APPLIES TO ALL LEADS.

  2. DIMENSION L APPLIES TO LEADS 1
  AND 3.

  3. DIMENSION Z DEFINES A ZONE WHERE
  ALL BODY AND LEAD IRREGULARITIES
  ARE ALLOWED.

  4. DIMENSIONING AND TOLERANCING PER
  ANSI Y14.5M. 1982.

  5. CONTROLLED DIMENSION: INFU.

143	MILLIN	ETERS	INC	HES	IIIII III
DIM	MIN	MAX	MIN	MAX	100
A	14.60	15.75	0.575	0.620	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
В	9.65	10.29	0.380	0.405	00 8
C	4.06	4.82	0.160	0.190	- 1 to 2 E
D	0.64	0.89	0.025	0.035	STYLE 1:
F	3.61	3.73	0.142	0.147	PIN 1. BASE
G	2.41	2.67	0.095	0.105	2. COLLECTOR
H	2.79	3.93	0.110	0.155	3. EMITTER
J	0.36	0.56	0.014	0.022	4. COLLECTOR
K	12.70	14.27	0.500	0.562	
L	1.14	1.39	0.045	0.055	2011111
N	4.83	5.33	0.190	0.210	\$0.0 do 040.0
0	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	CASE 221A-02
T	5.97	6.48	0.235	0.255	
U	0.00	1.27	0.000	0.050	(TO-220AB)
٧	1.14	-	0.045	-	
Z	-	2.03	-	0.080	

D44C Series

dNd



Characteristic	0.000	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS		UIGUAN)	VISITE OF	Argonald )	100000000000000000000000000000000000000	10000
Collector Cutoff Current (VCE = Rated VCES, VBE = 0)	es in CW	ICES	newoo mult	driver or me	10 secquia is	μΑ
Emitter Cutoff Current (VEB = 5.0 Vdc)		IEBO	- anisoloV s	er Saturatide	100	μА
ON CHARACTERISTICS			2000	nan Bundania	r Good Free	of at eligible da
^	44C/D45C2,3,5,6, 8,9,11,12 44C/D45C1,4,7,10	VCE(sat)	=	= 31	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)		V <sub>BE(sat)</sub>	-		1.3	Vdc
DYNAMIC CHARACTERISTICS					ines	MIMIUM RAT
Collector Capacitance (V <sub>C</sub> B = 10 Vdc, f = 1.0 MHz)	D44C Series D45C Series	C <sub>cb</sub>		100 125	=	pF Poting
Gain Bandwidth Product (I <sub>C</sub> = 20 mA, V <sub>CE</sub> = 4.0 Vdc, f = 20 MHz)	D44C Series D45C Series	45 T 60	30	50 40	oltage	ector SHMIter V
SWITCHING TIMES	207	0.0		887		TEL BRIDE ADILO
Delay and Rise Times (I <sub>C</sub> = 1.0 Adc, I <sub>B1</sub> = 0.1 Adc)	D44C Series	td + tr		100	Peak(1)	ns Power Dissip
	D45C Series	00	-	69 50	_17502	75-3840
Storage Time (I <sub>C</sub> = 1.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.1 Adc)	D44C Series D45C Series	Cat of da-		500	age <u>Ju</u> nction	TA = 20°C
Fall Time (I <sub>C</sub> = 1.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.1 Adc)	D44C Series D45C Series	t <sub>f</sub>	ludmoli	75 50	ac RACIERIS raciolistic	RMAL CHA
0 1	M/2°		RedC			rmel Resistance
FIGURE 1 — DC CURREN	T GAIN	10 FI	GURE 2 - N			VARD BIAS
TOTAL SECURITION OF THE SECURITIES OF THE SECURITION OF THE SECURITIES OF THE SECURITION OF THE SECURITIES OF THE SECURITION OF THE SECURI	V <sub>CE</sub> = 1.0 Vdc T <sub>J</sub> = 25°C	5.0 3.0 2.0	w2		10	μs μs ms
100 90 80 70 60		0.5 0.3	T <sub>C</sub> ≤ 70° Duty Cyc	dc °C le ≤ 50%		
90 80 70 60 50 40 ————————————————————————————————		0.2 0.1 0.05 0.05 0.03 0.02 0.01		D44C/45 D44C/45 D44C/45	C4,5,6	
0.04 0.05 0.07 0.1 0.2 0.3 0.4 0.5 0.7 I <sub>C</sub> , COLLECTOR CURRENT (AN		20	Name	5.0 7.0 10	20 30 VOLTAGE (VOL	50 70 10 TS)
				DARCT;A		

# NPN **D44E Series D45E Series**



#### **COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS**

... for general purpose power amplification and switching such as output or driver stages in applications such as switching regulators, converters and power amplifiers.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 2.0 V (Max) @ 10 A
- High DC Current Gain 1000 (Min) @ 5.0 Adc
- Complementary Pairs Simplifies Designs

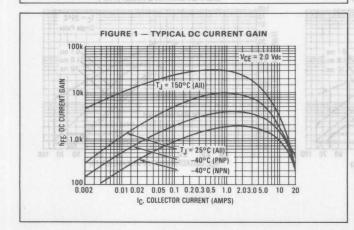
	DATINO
MAXIMUM	RAIINGS

mratimom materials						
D-4i	Symbol	D4	Unit			
Rating		1	2	3	Unit	
Collector-Emitter Voltage	VCEO	40	60	80	Vdc	
Emitter Base Voltage	VEB	7.0		7.0		Vdc
Collector Current — Continuous Peak (1)	IC	10 20		Adc		
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	50		Watts		
@ TA = 25°C	2.0	1.67				
Operating and Storage Junction Temperature Range	Tj,	-55 to 150		°C		

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	2.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

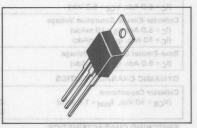
(1) Pulse Width ≤ 6.0 ms, Duty Cycle ≤ 50%.

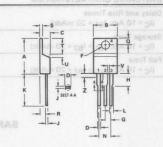


DARLINGTON 10 AMPERE

#### **COMPLEMENTARY SILICON POWER TRANSISTORS**

40-80 VOLTS 50 WATTS





- NOTES:
- NOTES:
  1. DIMENSION H APPLIES TO ALL LEADS.
  2. DIMENSION 1. APPLIES TO LEADS 1 AND 3 ONLY.
  3. DIMENSION 2 DEFINES A ZONE WHERE ALL.
  BODY AND LEAD IRREGULARITIES ARE
  ALLOWED.
  4. DIMENSIONING AND TOLERANCING PER ANSI
  '14.5.1973.
  5. CONTROLLING DIMENSION: INCH.

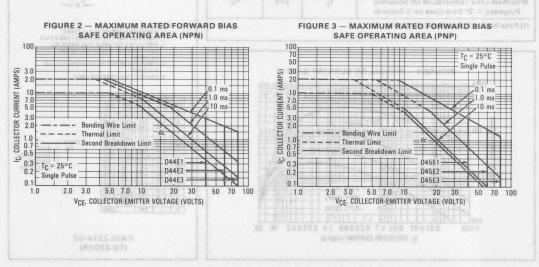


CASE 221A-02 (TO-220AB)

NPN
D44E Series
PNP
D45E Series

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					The state of the s	
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CEO</sub> , V <sub>BE</sub> = 0)	ators,	000	fica <del>ti</del> on a s svoh an	power ampli napplication		
Emitter Cutoff Current (V <sub>EB</sub> = 7.0 Vdc)		IEBO	- eparlsV			com Au era
ON CHARACTERISTICS (1)				A 01 @ (xsl	= 2.0 V (N	VCE(sat
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	-	h <sub>FE</sub> 35A	1000	15000		High DC .     Complem
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 20 mAdc)	-	V <sub>CE(sat)</sub>	=		1.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 10 mAdc)		V <sub>BE(sat)</sub>	_	-	2.5	Vdc Vdc
DYNAMIC CHARACTERISTICS	tioU -	2000 to 320		Symbol		Rating
Collector Capacitance (V <sub>CB</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	D44E Series D45E Series	ССВО	04	Veso - Ves		or Base Volta
SWITCHING CHARACTERISTICS	- obA	10		51	Continuous	oter Current -
Delay and Rise Times (I <sub>C</sub> = 10 Adc, I <sub>B1</sub> = 20 mAdc)	ensvV	t <sub>d</sub> + t <sub>r</sub>		0.6	nois	μs IgiasiC Towo9
Storage Time (I <sub>C</sub> = 10 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 20 mAdc)		ts	-	2.0	-	μSς = ΔΤ
Fall Time (I <sub>C</sub> = 10 Adc, I <sub>R1</sub> = I <sub>R2</sub> = 20 mAdc)		tf	-	918 0.5	_ eg	eP μS <sub>areq</sub>

# SAFE OPERATING AREA INFORMATION





# **COMPLEMENTARY SILICON POWER TRANSISTORS**

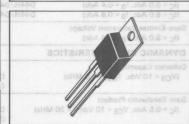
. . for general purpose power amplification and switching such as output or driver stages in applications such as switching regulators, converters and power amplifiers.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 V (Max) @ 8.0 A
- Fast Switching Speeds
- Complementary Pairs Simplifies Designs

# 10 AMPERETOARAND THE

#### **COMPLEMENTARY SILICON** POWER TRANSISTORS

30-80 VOLTS



#### **MAXIMUM RATINGS**

Rating	Symbol	1,2	4,5	7,8	10,11	Unit
Collector-Emitter Voltage	VCEO	30	45	60	80	Vdc
Emitter Base Voltage	VEB	5.0		- 500	Vdc	
Collector Current — Continuous Peak (1)	008 lc			0	251	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>A</sub> = 25°C	P <sub>D</sub>	50 1.67		801	Watts	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,	-55 to 150			°C	

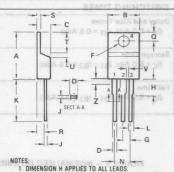
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	2.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta}JA$	75	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Width ≤ 6.0 ms, Duty Cycle ≤ 50%.

# ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
DC Current Gain (V <sub>CE</sub> = 1.0 Vdc, I <sub>C</sub> = 2.0 Adc)	D44H1,4,7,10 D45H1,4,7,10	h3 hFE	35	-10	7
6,5M23 6,5M23	D44H2,5,8,11 D45H2,5,8,11		60	-	
(V <sub>CE</sub> = 1.0 Vdc, I <sub>C</sub> = 4.0 Adc)	D44H1,4,7,10 D45H1,4,7,10	.0 20	20	01	LL.
	D44H2,5,8,11 D45H2,5,8,11		40	-	



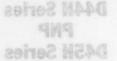
- 2. DIMENSION L APPLIES TO LEADS 1 AND 3
- AND 3.

  3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

  4. DIMENSIONING AND TOLERANCING PERANSI Y14.5 M., 1982.

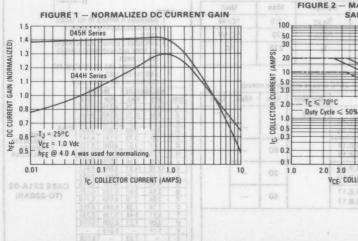
  5. CONTROLLING DIMENSION: INCH.

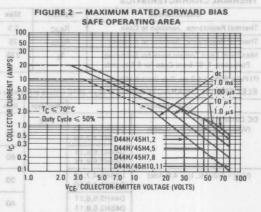
	1		T		7	
	MILLIN	IETERS	INC	HES		
DIM	MIN	MAX	MIN	MAX		
A	14.60	15.75	0.575	0.620		1 80
В	9.65	10.29	0.380	0.405		
C	4.06	4.82	0.160	0.190		
D	0.64	0.89	0.025	0.035	STYLE 1.	
F	3.61	3.73	0.142	0.147	PIN 1.	COLLECTOR
G	2.41	2.67	0.095	0.105	W 0. 2.	EMITTER
Н	2.79	3.93	0.110	0.155	A 8 A 6	COLLECTOR
J	0.36	0.56	0.014	0.022		COLLEGION
K	12.70	14.27	0.500	0.562		
L	1.14	1.39	0.045	0.055		
N	4.83	5.33	0.190	0.210	CASI	221A-0
0	2.54	3.04	0.100	0.120	0.7000000000000000000000000000000000000	
R	2.04	2.79	0.080	0.110	(TO	-220AB)
	1 1 4	1.20	0.045	0.055	1	





Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	SHOT	TRANSIS	REWOSI	Y SILICON	MENTAR	COMPLE
Collector Cutoff Current (VCE = Rated VCEO, VBE = 0)	as risus	ICES	a noitsaili	power small	10 seogragier	μA for gene
Emitter Cutoff Current (VEB = 5.0 Vdc)	julators,	IEBO	es ri <del>c</del> us àr	in application amplifiers.		outpager de converters a
ON CHARACTERISTICS				FIFE USE		
	H/D45H2,5,8,11 H/D45H1,4,7,10	VCE(sat)	- eg <u>sil</u> oV :	er Saturation Max) @ 8.0 P	1.0 <sup>0106</sup>	S Low Coll
Base-Emitter Saturation Voltage (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 0.8 Adc)		VBE(sat)	Designs	eds —	eq21.5 Ho	
DYNAMIC CHARACTERISTICS						
Collector Capacitance (V <sub>CB</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	D44H Series	C <sub>cb</sub>	_	130	_	pF
Gain Bandwidth Product (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 20 MHz)	D45H Series D44H Series D45H Series	fT	=	50 40	- NVGS	MHz
SWITCHING TIMES		GRN or DASH	3			
Delay and Rise Times (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 0.5 Adc)	D44H Series D45H Series	t <sub>d</sub> + t <sub>r</sub>	1,2 30	300 135	- sgalle	ns V ratim3-roto
Storage Time (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.5 Adc)	D44H Series D45H Series	t <sub>s</sub>	=	500 500	- Continuou Pea <u>ir (1)</u>	ns - totor Current
Fall Time (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = I <sub>B2</sub> = 0.5 Adc)	D44H Series D45H Series	tf Va.1	=	140	nolli	Powernisspi TC = 25°C







#### **COMPLEMENTARY SILICON POWER TRANSISTORS**

shot Min Typ Max Unit

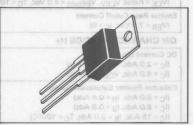
These complementary silicon power transistors are designed for high-speed switching applications, such as switching regulators and high frequency inverters. The devices are also well-suited for drivers for high power switching circuits.

- Fast Switching tf = 90 ns (Max)
- Key Parameters Specified @ 100°C
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.0 V (Max) @ 8.0 A
- Complementary Pairs Simplify Circuit Designs

#### 15 AMPERE

# COMPLEMENTARY SILICON POWER TRANSISTORS

30, 45, 60 and 80 VOLTS 83 WATTS



#### MAXIMUM RATINGS

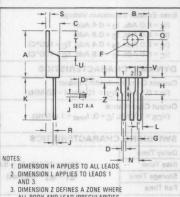
2	0	0	044VH (	or D45\	/H	11-14
Rating	Symbol	1	4	7	10	Unit
Collector-Emitter Voltage	VCEO	30	45	60	80	Vdc
Collector-Emitter Voltage	VCEV	50	70	80	100	Vdc
Emitter Base Voltage	VEB	-	7	.0		Vdc
Collector Current — Continuous Peak (1)	ICM	-		5		Adc
Total Power Dissipation OB  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD			13 67		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>		-55 t	o 150	1	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max 1.5 62.5	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Width ≤ 6.0 ms, Duty Cycle ≤ 50%.

Note 1: All polarities are shown for NPN transistors. For PNP transistors, reverse polarities. Note 2: See MJE5220/5230 Series data sheet for characteristic curves.



ALL BODY AND LEAD IRREGULARITIES
ARE ALLOWED.
4. DIMENSIONING AND TOLERANCING PER
ANSI Y14.5M. 1982.

ANSI Y14.5M, 1982.

	MILLIN	ETERS	INCHES			
DIM	MIN	MAX	MIN	MAX		
A	14.60	15.75	0.575	0.620		
В	9.65	10.29	0.380	0.405		
C	4.06	4.82	0.160	0.190		
D	0.64	0.89	0.025	0.035		
F	3.61	3.73	0.142	0.147		
G	2.41	2.67	0.095	0.105		
H	2.79	3.93	0.110	0.155		
J	0.36	0.56	0.014	0.022		
K	12.70	14.27	0.500	0.562		
L	1.14	1.39	0.045	0.055		
N	4.83	5.33	0.190	0.210		
0	2.54	3.04	0.100	0.120		
R	2.04	2.79	0.080	0.110		
S	1.14	1.39	0.045	0.055		
T	5.97	6.48	0.235	0.255		
U	0.00	1.27	0.000	0.050		
٧	1.14	-	0.045	-		
Z	-	2.03	-	0.080		

PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

(TO-220AB)



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# NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

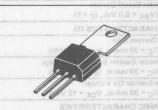
... designed for high-voltage TV video and chroma output circuits, high-voltage linear amplifiers, high-voltage drivers and high-voltage transistor regulators.

- High Collector-Emitter Breakdown Voltage BVCEO = 300 Vdc (Min) @ IC = 1.0 mAdc - MDS21
- Low Collector-Emitter Saturation Voltage -VCE(sat) = 0.6 Vdc (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance Ccb = 3.0 pF (Max) @ VCB = 20 Vdc
- Duowatt Package 2 Watts Free Air Dissipation @ TA = 25°C

#### DUOWATT

ELECTRICAL CHARACTERISTICS (TA = 25°C onless otherwise

### NPN SILICON **AMPLIFIER TRANSISTORS**

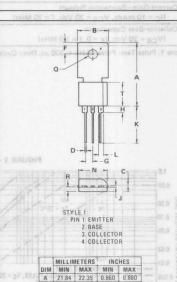


#### MAXIMUM RATINGS

Rating	Symbol	MDS20	MDS21	Unit
Collector-Emitter Voltage	VCEO	250 300		Vdc
Collector-Base Voltage	VCBO	250	300	Vdc
Emitter-Base Voltage	VEBO	8.0		Vdc
Collector Current — Continuous	ABICIO	OPERATIN	.5 AR MOI	Adc
Base Current	IB	0.	25	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	2.0 16		Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80		Watts mW/ <sup>o</sup> C
Operating and Storage Junction Company of the Park		ad to -55 to		°C
Solder Temperature, 1/16" from Case for 10 Seconds	endisions:	260		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W	
Thermal Resistance, Junction to Case	$R_{\theta}JC$	12.5	°C/W	



	MILLIN	METERS	INCHES			
MIG	MIN	MAX	MIN	MAX		
A	21.84	22.35	0.860	0.880		
В	9.91	10.41	0.390	0.410		
C	4.39	4.65	0.173	0.183		
D	0.58	0.74	0.023	0.029		
F	3.56	4.06	0.140	0.160		
G	2.41	2.67	0.095	0.105		
H	1.70	1.96	0.067	0.077		
J	0.48	0.66	0.019	0.026		
K	12.19	12.95	0.480	0.510		
L	1.65	2.03	0.065	0.080		
N	9.91	10.16	0.390	0.400		
0	3.56	3.81	0.140	0.150		
R	1.07	1.75	0.042	0.069		
T	7.87	9.14	0.310	0.360		

TO-202AC

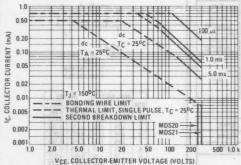
#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	MDS20 MDS21	BVCEO	250 300	_	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)	MDS20 MDS21	BVCBO	250 300	N <u>P</u> N SH	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)	88	BVEBO	8.0	NOLINGE	Vdc
Collector Cutoff Current (VCE = 150 Vdc, I <sub>B</sub> = 0) (VCE = 200 Vdc, I <sub>B</sub> = 0)	MDS20 MDS21		a TV video ene s, high-voltage	0.5 0.5	benµAdc egatlov-rigin
Collector Cutoff Current (V <sub>CB</sub> = 200 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 250 Vdc, I <sub>E</sub> = 0)	MDS20 MDS21	СВО	aloV n <del>w</del> obiles	0.1	μAdc
Emitter Cutoff Current (VBE = 6.0 Vdc, IC = 0)		<sup>1</sup> EBO	turation Volta	0.1 Croi-Emitter S	μAdc
ON CHARACTERISTICS (1)		nAde	06 = 31 @ (xs	(1) = 0.6 Vdc (N	VCE(sa
DC Current Gain (IC = 30 mAdc, VCE = 10 Vdc)		hFE	40 <sub>00000000000000000000000000000000000</sub>	250	Low Calle
Collector-Emitter Saturation Voltage (IC = 30 mAdc, IB = 3.0 mAdc)		V <sub>CE</sub> (sat)	10 A CT - 97 A	0.6	Vdc
Base-Emitter On Voltage (IC = 30 mAdc, VCE = 10 Vdc)		VBE(on)	ection @ TA =	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Prdouct (IC = 10 mAdc, VCE = 20 Vdc, f = 20 MHz)		fT	60		MHz
Collector-Base Capacitance (VCB = 20 Vdc, IE = 0, f = 1.0 MHz)		C <sub>cb</sub>	-	3.0	pF

Note 1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

#### TYPICAL CHARACTERISTICS

# FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be where the organized interestion that the discussion states the control of the co

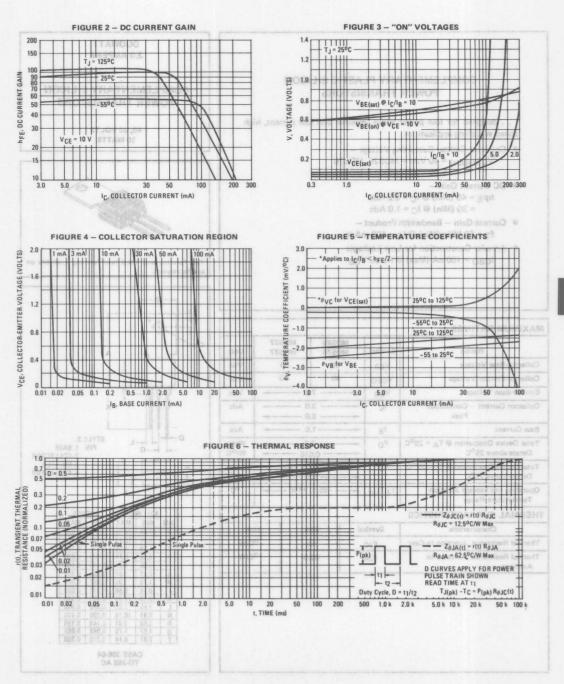
must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on  $TJ_{\{pk\}}=150^{0}\mathrm{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $TJ_{\{pk\}} \leqslant 150^{0}\mathrm{C}$ .  $TJ_{\{pk\}}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

NPN





#### TYPICAL CHARACTERISTICS (continued)



MDS26 MDS76 MDS27 MDS77



COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

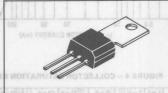
. . . designed for low power audio amplifier and low current, high speed switching applications.

- Collector-Emitter Sustaining Voltage –
   VCEO(sus) = 40 Vdc MDS26, MDS76
   = 60 Vdc MDS27, MDS77
- DC Current Gain —
   hFE = 40 (Min) @ I<sub>C</sub> = 0.2 Adc
   = 30 (Min) @ I<sub>C</sub> = 1.0 Adc
- Current-Gain Bandwidth Product –
   fT = 50 MHz (Min) @ IC = 100 mAdc
- Annular Construction for Low Leakages —
   ICBO = 100 nA (Max) @ Rated VCB

DUOWATT 3.0 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

> 40, 60 VOLTS 10 WATTS



Tab forming and TO-5 lead forming available on special request.

**MAXIMUM RATINGS** MDS26 MDS27 Rating Symbol Unit MDS76 MDS77 80 Vdc Collector-Base Voltage VCB 60 Collector-Emitter Voltage 40 60 Vdc VCEO Emitter-Base Voltage Vdc VEB - 7.0 -Collector Current - Continuous 3.0 IC Adc Peak 5.0 -10 -Base Current Adc Total Device Dissipation @ TA = 25°C 2.0 PD Watts Derate above 25°C W/OC 0.016 Total Device Dissipation @ T<sub>C</sub> = 25°C PD - 12.5 -Watts Derate above 25°C 100 mW/OC

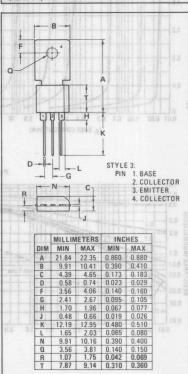
THERMAL CHARACTERISTICS

Operating and Storage Junction

Temperature Range

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	10	°C/W
Thermal Resistance, Junction to Ambient	θΙΑ	62.5	°C/W

 $T_{J}$ ,  $T_{stg}$ 



CASE 306-04 TO-202 AC

3

-65 to +150

°C

MDS60



Characteristic			S	ymbol	Min	Max	Unit	
FF CHARACTERISTICS	-sic	end do	id enin	tions amoi	urnoss soonau	for general-o	sanbiasib	
	S26,MDS76 S27,MDS77		_	VCEO(sus)	40 40	s, low saturations to the Naturation of the saturation of the satu	Vdc	
	26,MDS76 27,MDS77			СВО	=	0.1 0.1	μAdc	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 125°C) MDS26 (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 125°C) MDS27					_	0.1 0.1	mAdc	
Emitter Cutoff Current (VBE = 7.0 Vdc, IC = 0)	38/V		5430V	Ево	DA +	0.1	μAdc	
ON CHARACTERISTICS (1)	DOV		300	8	2×		sector dyse Voltees	
DC Current Gain	SEV SE A		500	hFE		orinopus	ner Para Voltrara	
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)			0.5 B1		40 30	200	f Power Dissipand water shove 25°C	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 20 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 600 mAdc)		0	V	CE (sat)		0.3 0.6 1.7	Vdc	
Base-Emitter Saturation Voltage (IC = 2.0 Adc, IB = 200 mAdc)	7652 W/751		V	BE (sat)		1.8	Vdc	
Base-Emitter On Voltage (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	W.36		V	BE(on)	_	1.5	Vdc	
OYNAMIC CHARACTERISTICS	-			Theran service	pa sesson 3,52 + 72	ROTERISTOR	AND JAMES	
Current-Gain — Bandwidth Product (2) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)				fT	50		MHz	
	26, MDS27 76, MDS77		300	C <sub>ob</sub>	-	50 70	pF e gs .abren d.l = t.less d.ess areas	
Pulse Test: Pulse Width $\leq 300 \ \mu s$ , Duty Cycle $\leq 2.0\%$ f <sub>T</sub> = $ h_{fe}  \bullet f_{test}$	20V		6.0		iltar čine Brasidova Variage = 10 #Add. 10 = 0s flecte Cotaff Current			
STYLE PIN I SMITTER T		0.0		Gast	6 Vdc. tp = 0) upolf Current 0. Vdc. tp = 0)			
3 COLLECTOR A COLLECTOR	-							
MAKE DMS 27 FK   MICHES   MI			25 36 36			erant Gala 1:0 nAde, V <sub>CE</sub> = 10 Vde) 10 nAde, V <sub>CE</sub> = 10 Vde) 30 nAde, V <sub>CE</sub> = 10 Vde)		
		L				in Emittar Sapratium Voltage (g = 20 mAde) (Filamos, 1g = 3.0 mAde) (Filamos, Charac, 1g = 3.0 mAde)		
918.0 08.00 12.85 0.00.0 2 186.0 08.00 20.5 06.1 3 600.0 08.0 08.00 18.9 45					is the			
		0.8			son Base Capeursones = 20 Vac. 1g = 0, (= 1.0.1Mes)			

. . . designed for general-purpose applications requiring high break down voltages, low saturation voltages and low capacitance.

Complement to NPN Type 2N6558

DUOWATT
PNP SILICON
HIGH VOLTAGE
TRANSISTOR

MAYIMIM PATINGS

MAXIMUM HATINGS			
SDA Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	300	Vdc
Collector-Base Voltage	VCB	300	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	IC	500	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	2.0 16	Watt mW/°C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	10	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> .T <sub>stg</sub>	-55 to +150	oC

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	12.5	oC/M
Thermal Resistance, Junction to Ambient	BJA 139	62.5	°C/W

# ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS 08				
Collector Emitter Breakdown Voltage(1) (IC = 1.0 mAdc, IB = 0)	BVCEO	300	-	Vdc
Collector-Base Breakdown Voltage (IC = 100 µAdc, IE = 0)	BVCBO	300		Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 μAdc, I <sub>C</sub> = 0)	BVEBO	5.0	-	Vdc
Collector Cutoff Current (VCB = 200 Vdc, IE = 0)	СВО	-	0.2	μAdc
Emitter Cutoff Current (V <sub>BE</sub> = 3.0 Vdc, I <sub>C</sub> = 0)	IEBO	-	0.1	μAdo

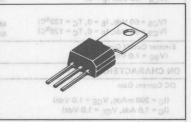
#### ON CHARACTERISTICS

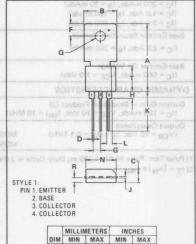
DC Current Gain	hFE			-
(IC = 1.0 mAdc, VCE = 10 Vdc)		25	-	
(IC = 10 mAdc, VCE = 10 Vdc)		30	-	
(IC = 30 mAdc, VCE = 10 Vdc)		30	-	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc)	VCE(sat)	-	0.75	Vdc
Base-Emitter Saturation Voltage (IC = 30 mAdc, IB = 3.0 mAdc)	VBE (sat)	-	0.9	Vdc

#### DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product (IC = 10 mAdc, VCE = 20 Vdc, f = 10 MHz)	fT	45		MHz
Collector-Base Capacitance (V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>cb</sub>	-	8.0	pF

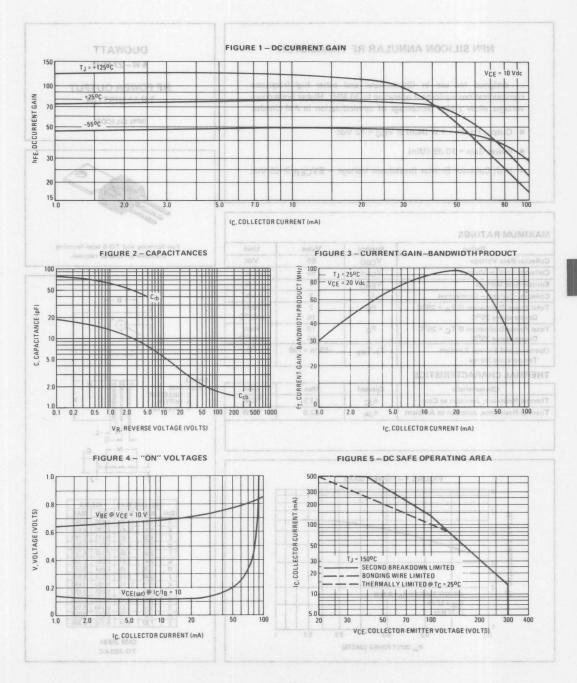
(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2%.





	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	21.84	22.35	0.860	0.880
В	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
F	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
Н	1.70	1.96	0.067	0.077
J	0.48	0.66	0.019	0.026
K	12.19	12.95	0.480	0.510
L	1.65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

CASE 306-04 TO-202 AC





#### NPN SILICON ANNULAR RF TRANSISTOR

... designed for use in Citizen-band and other high-frequency communications equipment operating to 30 MHz. Higher breakdown voltages allow a high percentage of up-modulation in AM circuits.

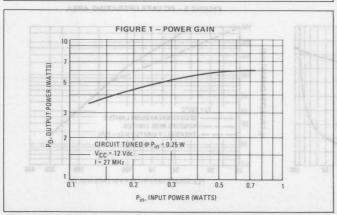
- Output Power = 4 W (Min) @ VCC = 12 Vdc
- Power Gain = 10 dB (Min)
- High Collector-Emitter Breakdown Voltage BVCER ≥ 65 Vdc

**MAXIMUM RATINGS** 

MAXIMOM NATINGS					
Rating	Symbol	Value	Unit		
Collector-Base Voltage	VCBO	65	Vdc		
Collector-Emitter Voltage	VCER	65	Vdc		
Emitter-Base Voltage	VEBO	4	Vdc		
Collector Current - Continuous	Ic	3	Adc		
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	2 16	Watt mW/ <sup>o</sup> C		
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10	Watt mW/ <sup>o</sup> C		
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C		

### THERMAL CHARACTERISTICS

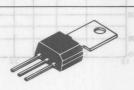
Characteristic	Symbol	Max	Unit
Thermal Reistance, Junction to Case	θЈС	12.5	°C/W
Thermal Resistance, Junction to Ambient	θJA SS	62.5	°C/W



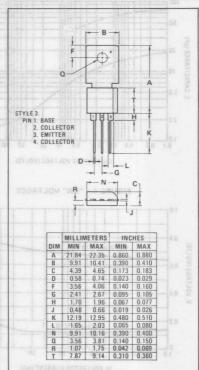
DUOWATT 4 W-27 MHz

RF POWER OUTPUT TRANSISTOR

NPN SILICON



Tab-forming and TO-5 lead-forming available on special request.



CASE 306-04

TO-202AC

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	·				
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 10 mAdc, R <sub>BE</sub> = 10 Ω)	BVCER	512 65 AST	N SILTCON	OLTAGE NP	Vdc
Emitter-Base Breakdown Voltage (IE = 1 mAdc, IC = 0)	BVEBO	es involves co	o high voltage		bins avotations
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0)	ІСВО	-		10.0 IoV Telmiter Vol	
ON CHARACTERISTICS				JAN - attoV 00E	- DBOV
DC Current Gain (2) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 5 Vdc)	hFE	15 10	_	Gain Specified or Emilter Satu	
Collector-Emitter Saturation Voltage (IC = 500 mAdc, IB = 50 mAdc)	VCE(sat)	-	90A30.1 =	5) as 50.4 6.9 -	- Vdc
DYNAMIC CHARACTERISTICS					
Output Capacitance (V <sub>CB</sub> = 12 Vdc, I <sub>E</sub> = 0, f = 1 MHz)	Cob	276128 0765	Symbol (III	45 2014	pF XAN
Current-Gain – Bandwidth Product (IC = 100 mAdc, VCE = 5 Vdc, f = 20 MHz)	t <sub>Tobby</sub>	000 000		- sgartu's	MHz MHz
FUNCTIONAL TEST (Figure 1)	- Vide	6.0	oay.	140	cristrer-Sase Volta
Common-Emitter Amplifier Power Gain (Pout = 4 W, V <sub>CC</sub> = 12 Vdc, f = 27 MHz)	GPE	10	2	Xon9	dB
Output Power (P <sub>in</sub> = 400 mW, V <sub>CC</sub> = 12 Vdc, f = 27 MHz)	Pout	4	<u>a</u> 9	stion © 1 € + 75 °C	Watts
Collector Efficiency (3) (P <sub>out</sub> = 4 W, V <sub>CC</sub> = 12 Vdc, f = 27 MHz)	η 30	-55 to ⇔50 -65 to +200	70	Temperatura Range te Rango	% made
Percentage Up-Modulation (4) (f = 27 MHz)	-	-	85	RACTERISTICS	% MERMAL CHA
	Harr	2000	leedmo2	sipile	offacyc/(1)

- (1) Pulsed through a 25 mH Inductor.
- (2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
- RFPout 100 (3)  $\eta = \frac{(V_{CC})(I_C)}{(V_{CC})(I_C)}$

**OUTPUT POWER (WATTS)** 

(4) Percentage Up-Modulation is measured in the test circuit (Figure 3) by setting the Carrier Power ( $P_c$ ) to 4 Watts with  $V_{CC}$  = 12 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V<sub>CC</sub> to 24 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

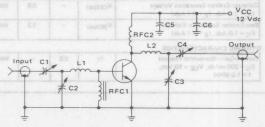
Percentage Up-Modulation =

### FIGURE 2 - OUTPUT POWER WITH VCC VARIATIONS

CIRCUIT TUNED @ VCC = 24 V, Pin = 0.2 W DUTY CYCLE = 25% P<sub>in</sub> = 0.6 W 0.4 W 0.2 W 10 VCC, COLLECTOR SUPPLY VOLTAGE (VOLTS)

- C1, C2 9.0 180 pF ARCO 463 or equivalent C3, C4 - 4.0-80 pF ARCO 462 or equivalent
- $C5-0.02~\mu F$  ceramic disc C6 - 0.1 µF ceramic disc
- RFC1 4 turns #30 enameled wire wound on ferroxcube bead
- type 56-590-65/3B
- $L1-0.22~\mu H$  molded choke L2 - 0.68 μH molded choke

#### FIGURE 3 - 27 MHz TEST CIRCUIT



# HIGH VOLTAGE NPN SILICON TRANSISTORS

. . designed for medium to high voltage inverters, converters, regulators and switching circuits.

- High Collector-Emitter Voltage VCEO = 200 Volts - MJ410 300 Volts - MJ411
- DC Current Gain Specified @ 1.0 and 2.5 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.8 Vdc @ IC = 1.0 Adc

MAXIMUM RATINGS

Rating	Symbol	MJ410	MJ410 MJ411			
Collector-Emitter Voltage	VCEO	200	300	Vdc		
Collector-Base Voltage	VCB	200	300	Vdc		
Emitter-Base Voltage	VEB	5.0		5.0		Vdc
Collector Current - Continuous Peak	Ic	5.0 10		Adc		
Base Current	1 <sub>B</sub>	2.0		Adc		
Total Device Dissipation @ T <sub>C</sub> = 75°C  Derate above 75°C	PD	100 1.33		Watts W/OC		
Operating Junction Temperature Range	TJ	-65 to +150		°C		
Storage Temperature Range	T <sub>stg</sub>	-65 t	o +200	°C		

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.75	°C/W

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	Pel to	iei Fower	ne Cari	Busines	AQ 15, 81
	MJ410 MJ411	VCEO(sus)	200 300	C 16 31	Vdc
. CL	MJ410 MJ411	CEO	-(0)	0.25 0.25	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 200 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 125°C)	MJ410	FACEX DA	- 60	0.5	mAdc
(V <sub>CE</sub> = 300 Vdc, V <sub>EB(off)</sub> · 1.5 Vdc, T <sub>C</sub> = 125°C)	MJ411	ramic disc	95 FA 1		
Emitter Cutoff Current (VEB = 5.0 Vdc, IC = 0)	6/38 Hemelo	IEBO .		5.0	mAdc

#### ON CHARACTERISTICS

DC Current Gain	hee	HILL BO	0-51	-
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		30	90	
(I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 5.0 Vdc)	URE3-37	10	-	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	V <sub>CE(sat)</sub>	-	0.8	Vdc
Base-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 0.1 Adc)	V <sub>BE</sub> (sat)	-	1.2	Vdc

#### DYNAMIC CHARACTERISTICS

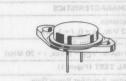
Current-Gain-Bandwidth Product		fT	2.5	
(IC = 200 mAdc, VCE = 10 Vdc,	M		1 8	57
f = 1.0 MHz)	Land V			The Said

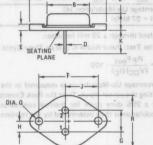
5 AMPERE

ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise not

# POWER TRANSISTORS NPN SILICON

200-300 VOLTS 100 WATTS





PIN 1. BASE

2. EMITTER NOTE:
CASE: COLLECTOR 1. DI 1. DIM "Q" IS DIA.

	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37		1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	- P	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
1	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67	- 19	1.050

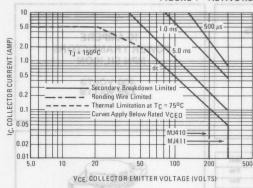
**CASE 11-01** TO-3

3

MHz



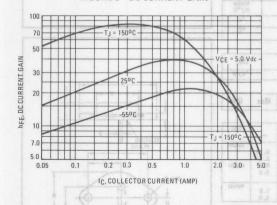
#### FIGURE 1 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided  $T_{J(Dk)} \le 150^{\circ}$ C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 2 - DC CURRENT GAIN



#### FIGURE 3 - "ON" VOLTAGES

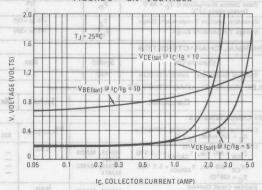


FIGURE 4 - SUSTAINING VOLTAGE TEST LOAD LINE

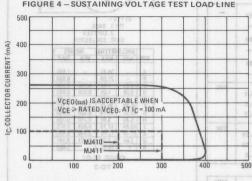
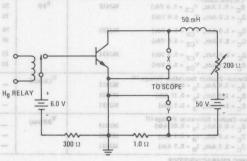


FIGURE 5 - SUSTAINING VOLTAGE TEST CIRCUIT



VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)



HIGH-VOLTAGE NPN SILICON TRANSISTORS

. . . designed for medium-to-high voltage inverters, converters, regulators and switching circuits.

- High Voltage V<sub>CEX</sub> = 400 Vdc
- Gain Specified to 3.5 Amp
- High Frequency Response to 2.5 MHz

#### MAXIMUM RATINGS

Rating	Symbol	MJ413	MJ423	MJ431	Unit
Collector-Emitter Voltage	VCEX	400	400	400	Vdc
Collector-Base Voltage	V <sub>CB</sub>	400	400	400	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	5.0	5.0	5.0	Vdc
Collector Current — Continuous	IC	10	10	10	Adc
Base Current	IB	2.0	2.0	2.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	P <sub>D</sub>	125 1, 0			Watts W/°C
Operation Junction Temperature Range	TJ	-65 to +150			°C
Storage Temperature Range	Tstg	-65 to +200			°C

TERMAL OFFICE TERMS TOS			
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	өдс	1.0	°C/W

# ELECTRICAL CHARACTERISTICS (T<sub>c</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
FF CHARACTERISTICS	THE	2		1%
Collector-Emitter Sustaining Voltage*(1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BV <sub>CEO(sus)</sub>	325	-12	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 400 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc) MJ413, MJ423 MJ431	ICEX	-	0.25	mAdc
(V <sub>CE</sub> = 400 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc, MJ413, MJ423 T <sub>C</sub> = 125°C) MJ431	0.05	=	0.5	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0) MJ413, MJ423 MJ431	I <sub>EBO</sub>	=	5.0	mAdc

#### ON CHAPACTERISTICS

ON CHARACTERISTICS					
DC Current Gain (1) $I_C = 0.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$ $(I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$	MJ413	h <sub>FE</sub>	20 15	80	T .
$(I_C = 1.0 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$ $(I_C = 2.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$	MJ423		30 10	90	
$(I_C = 2.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$ $(I_C = 3.5 \text{ Adc}, V_{CE} = 5.0 \text{ Vdc})$	MJ431	36	15 10	35	
Collector-Emitter Saturation Voltage (1) $(I_C = 0.5 \text{ Adc}, I_B = 0.05 \text{ Adc})$ $(I_C = 1.0 \text{ Adc}, I_B = 0.10 \text{ Adc})$ $(I_C = 2.5 \text{ Adc}, I_B = 0.5 \text{ Adc})$	MJ413 MJ423 MJ431	V <sub>CE</sub> (sat)	1,21	0.8 0.8 0.7	Vdc
$\begin{aligned} & \text{Base-Emitter Saturation Voltage'(1)} \\ & \text{(I)}_{\text{C}} = 0.5 \text{ Adc},  \text{I}_{\text{B}} = 0.05 \text{ Adc}) \\ & \text{(I)}_{\text{C}} = 1.0 \text{ Adc},  \text{I}_{\text{B}} = 0.1 \text{ Adc}) \\ & \text{(I)}_{\text{C}} = 2.5 \text{ Adc},  \text{I}_{\text{B}} = 0.5 \text{ Adc}) \end{aligned}$	MJ413 MJ423 MJ431	V <sub>BE</sub> (sat)	Ξ	1. 25 1. 25 1. 5	Vdc

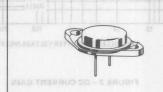
#### DYNAMIC CHARACTERISTICS

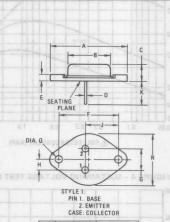
Current-Gain — Bandwidth Product (I <sub>C</sub> = 200 mAdc, V <sub>CR</sub> = 10Vdc,	f <sub>T</sub>	2.5	_	MHz
f = 1,0 MHz)				

(1) PW 4 300 μs, Duty Cycle 4 2.0%

#### 10 AMPERE **POWER TRANSISTORS NPN SILICON**

400 VOLTS 125 WATTS





	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	_	39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	1 (5.A)	3.43	21.5	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-	26.67		1.050

20

7.0

5.0

3.0

2.0

0.2 0.3

= 100°C

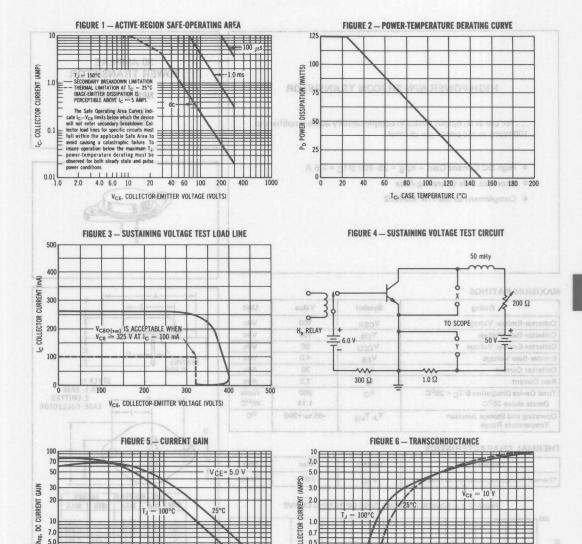
0.5 0.7 1.0

Ic. COLLECTOR CURRENT (AMP)

2.0

5.0 7.0 10





COLLECTOR CURRENT

0.7

0.5

0.3

0.2

15

VBE, BASE-EMITTER VOLTAGE (VOLTS)



#### HIGH-POWER NPN SILICON TRANSISTOR

... for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

• High DC Current Gain - hFE = 25-100 @ IC = 7.5 A

PROBRE 4 - SUSTAURING VOLTAGE TEST CRICURT

- Excellent Safe Operating Area
- Complement to the PNP MJ4502

30 AMPERE POWER TRANSISTOR

> NPN SILICON 100 VOLTS 200 WATTS

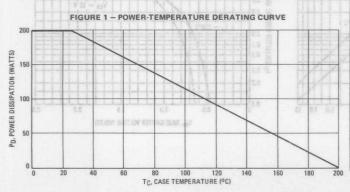


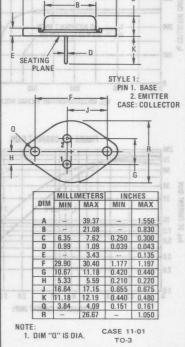
# MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCER	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	100	Vdc
Collector-Emitter Voltage	VCEO	90	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current	Ic/	30	Adc
Base Current	IB ODE	7.5	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	200 1.14	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.875	°C/W

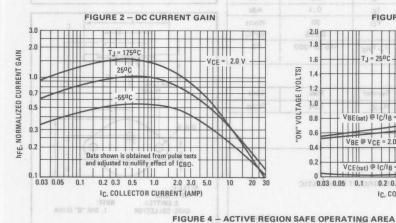


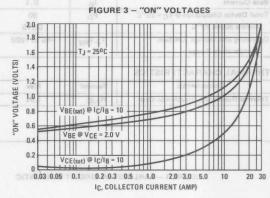


MOTOROLA

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

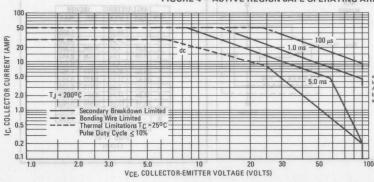
Characteristic			Symbo	l	Min	Max	Unit	
OFF CHARACTERISTICS								
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 200 mAdc, R <sub>BE</sub> = 100 Ohms)			BVCER		100	-	Vdc	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc)		Y	VCEO(si	us) qu	90 9W	DIUM-PO	Vdc	
Collector-Base Cutoff Current ( $V_{CB} = 100 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 100 \text{ Vdc}$ , $I_E = 0$ , $T_C = 150^{\circ}\text{C}$ )			СВО	ISISM	- -	1.0	mAdc	
Emitter-Base Cutoff Current (V <sub>BE</sub> = 4.0 Vdc, I <sub>C</sub> = 0)	pose	nuq lata	I <sub>EBO</sub>	mergrand	ut Saptor	1.0	mAdc	ms
ON CHARACTERISTICS (1)			e = 31 @ 1q	yT) 000	8 = 34# -	rent Gain	High DC Cu	
DC Current Gain (1) (I <sub>C</sub> = 7.5 Adc, V <sub>CE</sub> = 2.0 Vdc)			hFE	#8 nl-#	25 W	100	MonoHithic Shunt B	.0
Base-Emitter "On" Voltage (I <sub>C</sub> = 7.5 Adc, $V_{CE}$ = 2.0 Vdc)			V <sub>BE</sub> (on	)	-	1.3	Vdc	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>R</sub> = 0.75 Adc)			V <sub>CE</sub> (sat	)		0.8	Vdc	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>B</sub> = 0.75 Adc)			V <sub>BE</sub> (sat	)	-	1.3	Vdc	UNAI
DYNAMIC CHARACTERISTICS	tinU	roeu	A COSTA	lodmy	8		Bating	
Current Gain – Bandwidth Product (IC = 1.0 Adc, VCE = 10 Vdc, f = 1.0 MHz)	Vdc	98	0°fT	0.80	2.0	_ 090	MHz	101
	SbV	1 1001	0.8	8JV		1	sparioV sas	1
Pulse Test: Pulse Width≤ 300 μs, Duty Cycle ≤ 2.0%.								





M1900, M1901 PNP

MITOGO, MITOGI NPN



The Safe Operating Area Curves indicate  $I_{C} - V_{CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_{J_{C}}$  power-temperature derating must be observed for both steady state and pulse power conditions.



# MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain hFE = 6000 (Typ) @ IC = 3.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

8.0 AMPERE DARLINGTON POWER TRANSISTORS **COMPLEMENTARY SILICON** 

> 60-80 VOLTS 90 WATTS

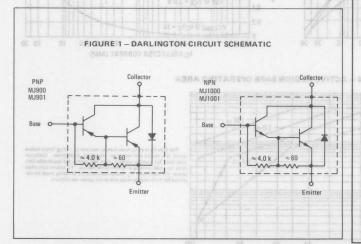
#### MAXIMUM RATINGS

Rating	Symbol	MJ900 MJ1000	MJ901 MJ1001	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current	1 <sub>C</sub>	8.0		Adc
Base Current	I <sub>B</sub>	0.1		Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	90		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +200		°C

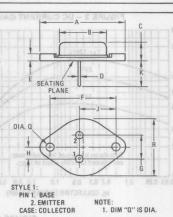
VBEIsati

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	ReJC	1.94	°C/W	







DIM	MIN	MAX	MIN	MAX
A	-	39.37		1.550
В	-	21.08		0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	-500	26.67	gnileno/)	1.050
		CASE 11 (TO-3)	-01	

# MJ900, MJ901 PNP/MJ1000, MJ1001 NPN

PNP	10	MJ25	500,	MJ2
MSM	100	MJ30	,000	ELM

ELECTRICAL CHARACTERISTICS (TC = 25°C unless other	wise noted)

AJOROTOROLA

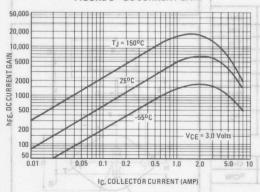
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ900, MJ1000 MJ901, MJ1001	BVCEO	60 80		Vdc
Collector Emitter Leakage Current (V <sub>CB</sub> = 60 Vdc, R <sub>BE</sub> = 1,0 k ohm) (V <sub>CB</sub> = 80 Vdc, R <sub>BE</sub> = 1.0 k ohm, T <sub>C</sub> = 150°C) (V <sub>CB</sub> = 60 Vdc, R <sub>BE</sub> = 1.0 k ohm, T <sub>C</sub> = 150°C) (V <sub>CB</sub> = 80 Vdc, R <sub>BE</sub> = 1.0 k ohm, T <sub>C</sub> = 150°C)	MACCO	ICER	COMPLEMENTA	1.0 1.0 5.0 5.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	IMOO	IEBO	SHULSIEMAZ	2.0	mAdc
Collector-Emitter Leakage Current $(V_{CE} = 30 \text{ Vdc}, I_{B} = 0)$ $(V_{CE} = 40 \text{ Vdc}, I_{B} = 0)$	MJ900, MJ1000 MJ901, MJ1001	ICEO SEOQUIQ ISTANS	n complementary (		μAdc szu tol
ON CHARACTERISTICS					
DC Current Gain(1) (IC = 3.0 Adc, VCE = 3.0 Vdc) (IC = 4.0 Adc, VCE = 3.0 Vdc)			1000 1000	ment Gain - hpg Construction with	sidulanoM e
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 12 mAdc) (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 40 mAdc)		VCE (sat)		2.0 4.0	Vdc

VBE

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

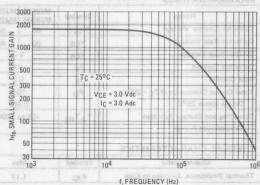
Base-Emitter Voltage(1) (I<sub>C</sub> = 3.0 Adc, V<sub>CE</sub> = 3.0 Vdc)

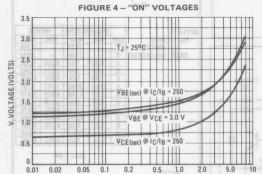
#### FIGURE 2 - DC CURRENT GAIN



#### FIGURE 3 - SMALL-SIGNAL CURRENT GAIN

Vdc





IC, COLLECTOR CURRENT (AMP)

There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C-V_{CE}$  limits of the transistor that must be observed for reliable operation; e.g., the transistor

#### FIGURE 5 - DC SAFE OPERATING AREA 10 7.0 COLLECTOR CURRENT (AMPS) 5.0 3.0 2.0 1.0 SECONDARY BREAKDOWN LIMITATION 0.7 THERMAL LIMITATION @ TC = 25°C 0.5 BONDING WIRE LIMITATION 0.3 MJ900, MJ1000 0.2 MJ901, MJ1001 0.1 5.0 7.0 10 20 1.0

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

must not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MJ900, MJ901 PNP/MJ1000, MJ1001 NPN

#### MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

 $\ldots$  , for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain hFE = 4000 (Typ) @ IC = 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter
   Shunt Resistors

# 10 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60-80 VOLTS 150 WATTS

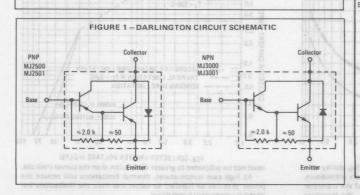


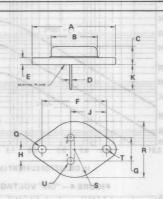
#### MAXIMUM RATINGS

Rating	Symbol	MJ2500 MJ3000	MJ2501 MJ3001	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current	Ic	10		Adc
Base Current	IB	0.2		Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	P <sub>D</sub>	150 0.857		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	or Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W

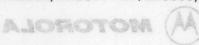




LE 1			MILLIMETERS		INCHES		
PIN 1.	BASE	DIM	MIN	MAX	MIN	MAX	
2.	EMITTER	A	141	39.37		1,550	
CASE	COLLECTOR	В	11411	21.08	_	0.830	
	C	6.35	7.62	0.250	0.300		
	D	0.97	1.09	0.038	0.043		
		E	1.40	1.78	0.055	0.070	
		F	29.90	30.40	1.177	1,197	
		G	10.67	11.18	0.420	0.440	
		H	5.33	5.59	0.210	0.220	
		J	16.64	17.15	0.655	0.675	
		K	11.18	12.19	0.440	0.480	
		0	3.81	4.19	0.150	0.165	
		R	4	26.67	-	1.050	
		U	2.54	3.05	0.100	0.120	
			CASE 1-04				

NOTES:

1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO 3 OUTLINE SHALL APPLY.





FI	ECTRICAL	CHARACTERISTICS	(To = 2500	unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ2500, MJ3000 MJ2501, MJ3001	BVCEO	60 80	_	Vdc
Collector Emitter Leakage Current (VCB = 60 Vdc, RgE = 1.0 k ohm) (VCB = 80 Vdc, RgE = 1.0 k ohm, TC = 150°C) (VCB = 80 Vdc, RgE = 1.0 k ohm, TC = 150°C)	MJ2500, MJ3000 MJ2501, MJ3001 MJ2500, MJ3000 MJ2501, MJ3001		OLTAGE TRAN	1.0	
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		l <sub>EBO</sub>		2.0	mAdc
Collector-Emitter Leakage Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	MJ2500, MJ3000 MJ2501, MJ3001	ICEO		us) = 2 0.1 Vdc (M 3 0.1 Vdc (M	mAdc WAR
ON CHARACTERISTICS (1)			Deflection —	lamosinoH ni emi	# Fast Fall Ti
DC Current Gain		hFE (	EGELM 1000 DV 08	us (Max F0 VCC =	0.1 = 11 -

ON CHARACTERISTICS (1)		Deflection -		Fast Fall T
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	hFE (	EGCLM 1000 5V 08	= DDA @HXRM) sh	D.F = 11 =
Collector-Emitter Saturation Voltage {IC = 5.0 Adc, IB = 20 mAdc} (IC = 10 Adc, IB = 50 mAdc)	VCE(sat) OSOSL	te = 0.95 (Min) — N	2.01 SIA A	O S NO Vac
Base-Emitter Voltage (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	V <sub>BE</sub>	-	3.0	Vdc

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

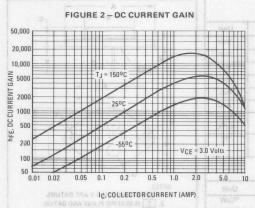


FIGURE 3 - SMALL-SIGNAL CURRENT GAIN XAM

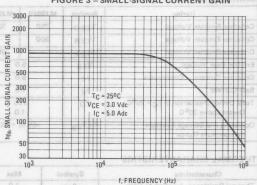
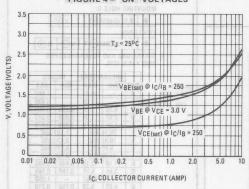
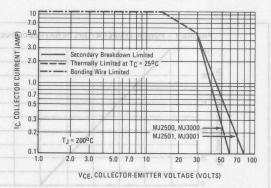


FIGURE 4 - "ON" VOLTAGES



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate  $1_{\rm C}{-}{\rm V}_{\rm CE}$  limits of the transistor that must be observed for reliable operation; e.g., the transistor must

FIGURE 5 - DC SAFE OPERATING AREA



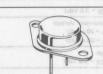
not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

#### NPN SILICON HIGH-VOLTAGE TRANSISTORS

. . . designed for TV horizontal and vertical deflection amplifier circuits.

- High Collector-Emitter Sustaining Voltage VCEO(sus) = 250 Vdc (Min) MJ3029 325 Vdc (Min) MJ3030
- Fast Fall Time in Horizontal Deflection tf = 1.0 μs (Max) @ VCC = 80 Vdc - MJ3030
- Excellent Gain Linearity for Vertical Deflection hfe @ 0.4 Adc, hfe @ 0.3 Adc = 0.95 (Min) - MJ3029

5 AMPERE POWER TRANSISTORS NPN SILICON 250-325 VOLTS 125 WATTS - 30 - 30

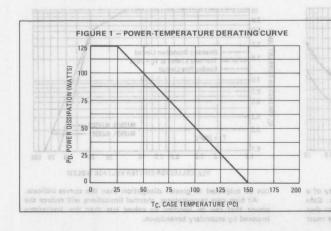


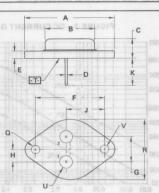
#### MAXIMUM BATINGS

Rating	Symbol	MJ3029	MJ3030	Unit
Collector-Emitter Voltage	VCEO	250	325	Vdc
Collector-Emitter Voltage	VCER	500	<u> </u>	Vdc
Collector-Emitter Voltage	VCEX	0	700	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current — Continuous	Ic	5	.0	Adc
Base Current	IB	1	.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD		.0	Watts W/OC
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 t	o +150	°C

#### THERMAL CHARACTERISTICS

THEMMAL CHAMACTEMOTICS	Deta:	Ent	5.0 10
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ.IC.	1.0	°C/W





#### NOTES:

- 1. DIMENSIONS Q AND V ARE DATUMS.
- 2. T. IS SEATING PLANE AND DATUM.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:

+	Ø.13 (0.005) №	T	V M
FORL	EADS:	1	

- ♦ 0.13 (0.005) M T VM QM
- 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	-	MILLIN	METERS	INC	HES
TYLET	DIM	MIN	MAX	MIN	MAX
PIN 1 BASE	A		39.37	-	1.550
2 EMITTER CASE COLLECTOR	В	1000	21.08	-	0.830
V D.A BOY O	C	6.35	7.62	0.250	0.300
	D	0.97	1.09	0.038	0.043
The self-self-self-self-self-self-self-self-	E	1.40	1.78	0.055	0.070
	F	30.15	BSC	1.187	7 BSC
	G	10.92	BSC	0.430	BSC
	Н	5.46	BSC	0.215	BSC
	J	16.89	BSC	0.665	BSC
	K	11.18	12.19	0.440	0.480
	0	3.81	4.19	0.150	0.165
	R	DEFE	26.67		1.050
	U	4.83	5.33	0.190	0.210
	٧	3.81	4.19	0.150	0.165

and yre bocase bos end CASE 1-05 Obcasous

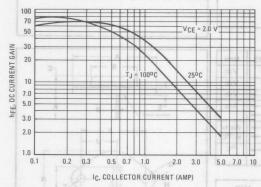


ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

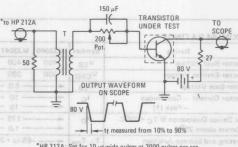
Characteristic		Symbol	Min	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (IC = 0.1 Adc, IB = 0)	MJ3029 MJ3030	VCEO(sus)	250 325	TAGE	Vdc	
Collector Cutoff Current (V <sub>CE</sub> = 500 Vdc, R <sub>BE</sub> = 1.5 k Ohms)	MJ3029	ICER	GTONS	ALJAAO	mAdc	
Collector Cutoff Current (V <sub>CE</sub> = 700 Vdc, V <sub>EB(off)</sub> = 1.5 Vdc)	MJ3030	ICEX		2.0	mAdc	
ON CHARACTERISTICS	Simportari	cim cond co.	son Carlanda	or one code	anii sol ba	
DC Current Gain (I <sub>C</sub> = 0.3 Adc, V <sub>CE</sub> = 5.0 Vdc)(1) (I <sub>C</sub> = 0.4 Adc, V <sub>CE</sub> = 5.0 Vdc)(1)	MJ3029 MJ3029	hFE 1 hFE 2	25 30	-	.sno <u>n</u> s.sn	
Gain Linearity	MJ3029	hFE 2	0.95°511 0.00°ELM —		Fmitter Su 300 = 300	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.8 Adc)	MJ3030	VCE(sat)	- MJ3042	2.0	Vdc	
SWITCHING CHARACTERISTICS		ON	ELIST SEA	20 - 10		
Fall Time (V <sub>CC</sub> = 80 Vdc, I <sub>C</sub> = 3.0 Adc, I <sub>R1</sub> = 0.8 Adc) Figure 3	MJ3030	FOEFILING		2 1.0	A STATE OF THE PARTY OF THE PAR	

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

#### FIGURE 2 - DC CURRENT GAIN

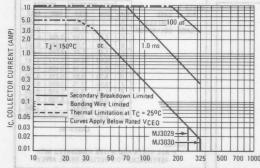


#### FIGURE 3 - TEST FOR FALL TIME



\*HP 212A: Set for 10  $\mu$ s wide pulses at 2000 pulses per sec. (500  $\mu$ s intervals). Adjust for I $\beta$ 1 = 0.8 A. Bias: Adjust to 1.5 V on a VTVM across the 200  $\Omega$  Pot. T: Pulse Transformer: Motorola Part No. 25D68782A01.

#### FIGURE 4 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate |C-VCE| limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

DARLINGTON SCHEMATIC

The data of Figure 4 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)



#### HIGH VOLTAGE SILICON POWER DARLINGTONS

. . . developed for line operated amplifier, series pass and switching regulator applications.

- Collector-Emitter Sustaining Voltage -VCEO(sus) = 300 Vdc (Min) - MJ3040, MJ3041 = 350 Vdc (Min) - MJ3042
- High DC Current Gain -

hFE = 100 (Min) @ IC = 2.5 Adc -- MJ3040 = 250 (Min) @ IC = 2.5 Adc - MJ3041, MJ3042

- Low Collector-Emitter Saturation Voltage VCE(sat) = 2.2 Vdc (Max) @ IC = 2.5 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

DARLINGTON 10 AMPERE **POWER TRANSISTORS** NPN SILICON

> 300, 350 VOLTS 175 WATTS

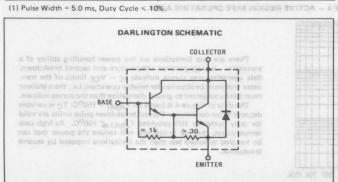


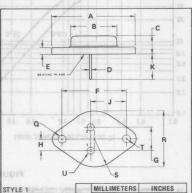
MAXIMUM RATINGS

MAXIMO MILATINGO	VIVS 4		H1000		
Rating	Symbol	MJ3040	MJ3041	MJ3042	Unit
Collector-Base Voltage	VCB	400	400	500	Vdc
Collector-Emitter Voltage	VCEO	300	300	350	Vdc
Emitter-Base Voltage MADARVAW	VEB	4	<del>- 8.0 -</del>	-	Vdc
Collector Current — Continuous — Peak (1)	Ic.	-	— 10 — — 15 —		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	-	— 175 — — 1.0 —		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	*HP 212A:	65 to +20	00	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.0	°C/W

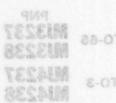




	41170	MILLIN	METERS	INC	HES
BASE	DIM	MIN	MAX	MIN	MAX
EMITTER	A	-	39.37	or other t	1.550
COLLECTOR	В		21.08		0.830
	C	6.35	7.62	0.250	0.300
	D	0.97	1.09	0.038	0.043
	E	1.40	1.78	0.055	0.070
	F	29.90	30.40	1.177	1.197
	G	10.67	11.18	0.420	0.440
	H	5.33	5.59	0.210	0.220
	J	16.64	17.15	0.655	0.675
	K	11.18	12.19	0.440	0.480
	0	3.81	4.19	0.150	0.165
	R	17 22015	26.67	-	1.050
	U	2.54	3.05	0.100	0.120

CASE

1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.



Max

Unit

#### **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted.)

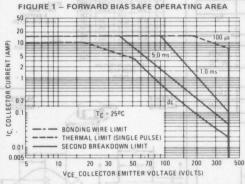
Characteristic

Onlaracteristic	O y moon		111011		
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ3040, MJ3041 MJ3042	VCEO(sus)	300 350	COMPLEN	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 400 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 500 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 400 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 100°C) (V <sub>CB</sub> = 500 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 100°C)	MJ3040, MJ3041 MJ3042 MJ3040, MJ3041 MJ3042	ICBO s oithus in stevin serecimA	gh-frequency d ecified_te 4.0	1.0 1.0 5.0 5.0	mAdc rogiceb
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	Pic ≈ 4.0 Add	(niM) 00 = 40,	mAdc

Symbol

ON CHARACTERISTICS					Vdc (Min)	= 120	
(IC - 2.5 Adc, VCE - 5.0 Vdc)	MJ3041, I	MJ3040 MJ3042		hFE duct	100 250	Current Gain	rigiH •
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	MJ3041, I	MJ3040 MJ3042		nAdc .	50	= 20 MHz (M	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.5 Adc, I <sub>B</sub> = 50 mAdc)				VCE (sat)	_	2.2	Vdc
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 400 mAdc)			14248 14238	MAJESET N	-	2.5	
Base-Emitter Saturation Voltage (IC = 5.0 Adc, IR = 400 mAdc)	SORTAGE 3	Unit	\$22.38 \$32.38	V <sub>BE</sub> (sat)	Jodeny2	3.0	Aft Vdc
THE STATE OF THE S			081	120	osoV	agaslo	
Base-Emitter On Voltage		obV.	-081	VBE(on)	L Vcs.	2.5	Vdc
(I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 5.0 Vdc)					saV -	2.5	getioV azeB-ratti

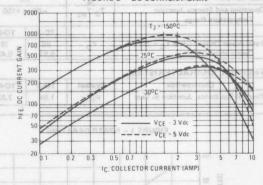




There are two limitations on the power handling ability of a transistor — average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)} = 150^{\circ}C$ :  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### FIGURE 2 - DC CURRENT GAIN



TO-3 MJ42

MJ3238 MJ4237



## COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for use as high-frequency drivers in audio amplifiers.

• DC Current Gain Specified to 4.0 Amperes

hFE = 40 (Min) @ IC = 3.0 Adc

= 20 (Min) @ I<sub>C</sub> = 4.0 Adc

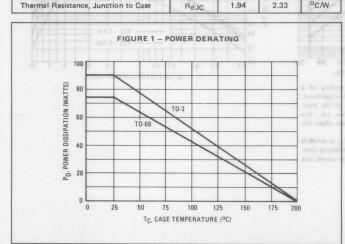
Collector-Emitter Sustaining Voltage -

V<sub>CEO(sus)</sub> = 120 Vdc (Min) = 150 Vdc (Min)

• High Current Gain - Bandwidth Product

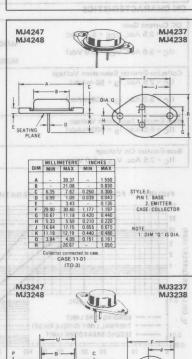
f<sub>T</sub> = 20 MHz (Min) @ I<sub>C</sub> = 500 mAdc

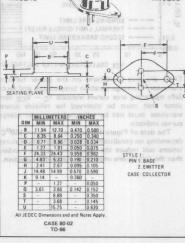
aby RATING as	Symbol	MJ4247 MJ4237 MJ3247 MJ3237	MJ4248 MJ4238 MJ3248 MJ3238	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	120	150	Vdc
Collector-Base Voltage	V <sub>CB</sub>	120	150	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current — Continuous Peak	1 <sub>C</sub>		.0	Adc
Base Current - Continuous 1900 30 -	s sautes	2	.0	Adc
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150		°C
		TO-3	TO-66	Tay INV
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	90 0.51	75 0.43	Watts W <sup>O</sup> C
THERMAL CHARACTERISTICS		000	ENT	100
Characteristic	Symbol	TO-3	TO-66	Unit
Thermal Resistance, Junction to Case	ReJC	1.94	2.33	°C/W



# 8 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

120-150 VOLTS 75 WATTS - TO-66 90 WATTS - TO-3





Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		MASS.		6,2
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0) MJ4237, MJ4247, MJ3237, MJ3247 MJ4238, MJ4248, MJ3238, MJ3248	VCEO(sus)	120 150		Vdc
Collector Cutoff Current (V <sub>CE</sub> = 120 Vdc, I <sub>B</sub> = 0) MJ4237, MJ4247, MJ3237, MJ3247 (V <sub>CE</sub> = 150 Vdc, I <sub>B</sub> = 0) MJ4238, MJ4248, MJ3238, MJ3248	CEO	-	0.1 0.1	mAdc
Collector Cutoff Current (V <sub>CB</sub> = 120 Vdc, I <sub>E</sub> = 0) MJ4237, MJ4247, MJ3237, MJ3247 (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) MJ4238, MJ4248, MJ3238, MJ3248	СВО	1 1-1	10	μAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)	<sup>I</sup> EBO	-	10	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain  (I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 2.0 Vdc)  (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)  (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 2.0 Vdc)  (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	h <sub>FE</sub>	40 40 40 20		- 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0
DC Current Gain Linearity (V <sub>CE</sub> From 2.0V to 20V, I <sub>C</sub> From 0.1A to 3A) (NPN TO PNP)	h <sub>FE</sub>		Typ 2 3	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	VCE(sat)	H-P	0.5	Vdc

VBE(on)

fT

(I<sub>C</sub> = 500 mAdc,  $V_{CE}$  = 10 Vdc,  $f_{test}$  = 10 MHz) (1)Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

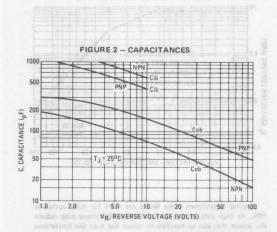
(2)f<sub>T</sub> = |h<sub>fe</sub>| • f<sub>test</sub>

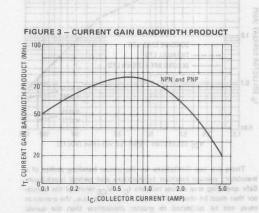
Base-Emitter On Voltage

(I<sub>C</sub> = 1.0 Adc, V<sub>CE</sub> = 2.0 Vdc)

DYNAMIC CHARACTERISTICS

Current Gain — Bandwidth Product (2)



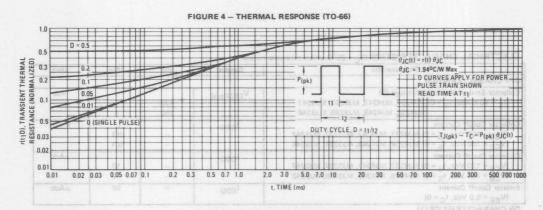


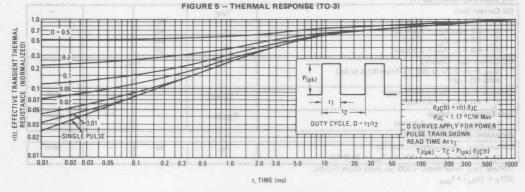
1.0

20

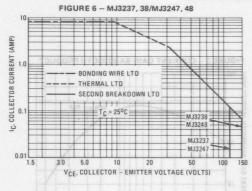
Vdc

MHz

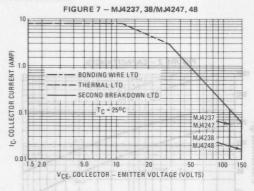




#### FORWARD BIAS SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\hbox{\scriptsize C}}-V_{\hbox{\scriptsize CE}}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

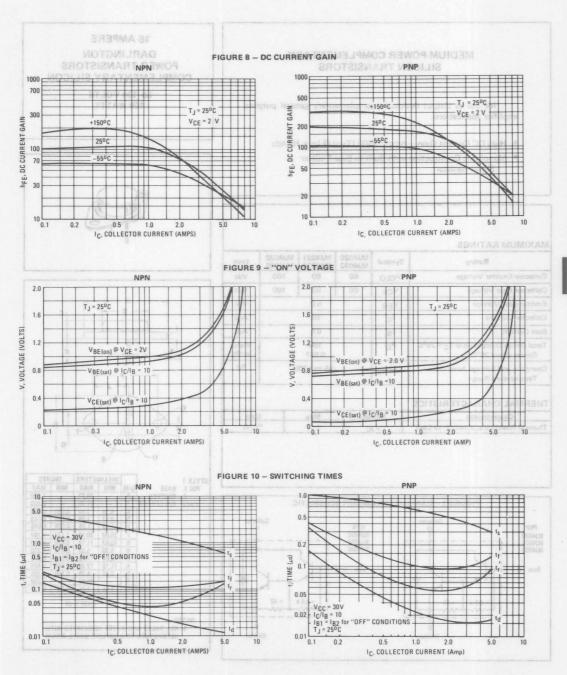


Second breakdown pulse limits are valid for duty cycles to 10%. At high case temperatures, thermal limitations may reduce the power that can be handled to values less than the limitations imposed by second breakdown.

MOTOROLA

MJ4030, MJ4031, MJ4032 PNP

MJ4033, MJ4034, MJ4035 NPN





## MEDIUM-POWER COMPLEMENTARY DO SO A SERVICE SILICON TRANSISTORS

 $\,$  . . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain hFE = 3500 (Typ) @ IC = 10 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor

#### MAXIMUM RATINGS

Rating	Symbol	MJ4030 MJ4033	MJ4031 MJ4034	MJ4032 MJ4035	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	5.0			Vdc
Collector Current	1c	16			Adc
Base Current	IB	0.5		27.	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	150 0.857		UE UND	Watts W/OC
Operating and Storage Junction Temperature Range	TJ,T <sub>stg</sub>	18	-55 to +20	0	°C

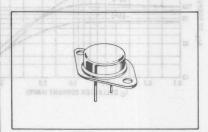
#### THERMAL CHARACTERISTICS

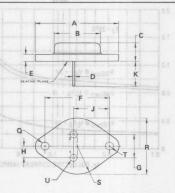
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.17	°C/W

# FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC Collector NPN MJ4033 MJ4033 MJ4033 MJ4035 Base Emitter Emitter Emitter Emitter

# 16 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60-100 VOLTS 150 WATTS





STYLE 1			MILLIN	METERS	INC	HES
PIN 1.	BASE	DIM	MIN	MAX	MIN	MAX
2.	EMITTER	A	-	39.37		1.550
CASE	COLLECTOR	В	-	21.08	_	0.830
		C	6.35	7.62	0.250	0.300
		D	0.97	1.09	0.038	0.043
		E	1.40	1.78	0.055	0.070
	- American	F	29.90	30.40	1.177	1.197
		G	10.67	11.18	0.420	0.440
		Н	5.33	5.59	0.210	0.220
		J	16.64	17.15	0.655	0.675
		K	11.18	12.19	0.440	0.480
		Q	3.81	4.19	0.150	0.165
		R	-	26.67	121	1.050
		U	2.54	3.05	0.100	0.120
			2.54			

NOTES:

1. ALL RULES AND NOTES ASSOCIATED WITH
REFERENCED TO-3 OUTLINE SHALL APPLY.

MIASO2

## MJ4030, MJ4031, MJ4032 PNP/MJ4033, MJ4034, MJ4035 NPN

No. 17876, 4010	FOR LIGHTING. Y	1 B B V	
	7. 65. 70	1000	

Characteristic		Symbol	Min	Max	Unit
FF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ4030, MJ4033 MJ4031, MJ4034 MJ4032, MJ4035	BVCEO	60 80 100	- 2	Vdc
Collector Emitter Leakage Current (VCg = 60 Vdc, Rgg = 1.0 k ohm) (VCg = 80 Vdc, Rgg = 1.0 k ohm) (VCg = 100 Vdc, Rgg = 1.0 k ohm) (VCg = 100 Vdc, Rgg = 1.0 k ohm, TC = 150°C) (VCg = 80 Vdc, Rgg = 1.0 k ohm, TC = 150°C) (VCg = 100 Vdc, Rgg = 1.0 k ohm, TC = 150°C)	MJ4030, MJ4033 MJ4031, MJ4034 MJ4032, MJ4035 MJ4030, MJ4033 MJ4031, MJ4034 MJ4032, MJ4035	ICER	11.11.1	1.0 1.0 1.0 5.0 5.0 5.0	mAdc.
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	ONUSHI PRODI	5.0	mAdc
Collector-Emitter Leakage Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 40 Vdc, I <sub>B</sub> = 0) (VCE = 50 Vdc, I <sub>B</sub> = 0)	MJ4030, MJ4033 MJ4031, MJ4034 MJ4032, MJ4035	raintama pibu		3.0 3.0 49100 f	
N CHARACTERISTICS(1)					
DC Current Gain (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc)		hFE _A	8,7 = 01000	ant Gain — hpg = 1	a High DC Curr

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 2 - DC CURRENT GAIN

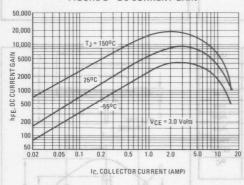


FIGURE 3 - SMALL-SIGNAL CURRENT GAIN

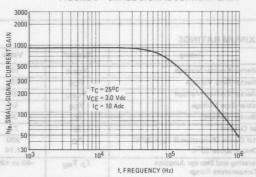
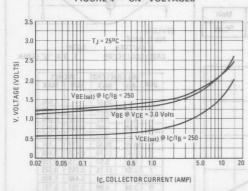
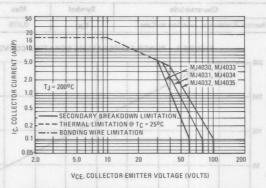


FIGURE 4 - "ON" VOLTAGES



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C\!-\!V_CE$  limits of the transistor that must be observed for reliable operation; e.g., the transistor

FIGURE 5 - DC SAFE OPERATING AREA



must not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

# MOTOROLA

#### HIGH-POWER PNP SILICON TRANSISTOR

. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain hFE = 25-100 @ IC = 7.5 A
- Excellent Safe Operating Area
- Complement to the NPN MJ802

#### 30 AMPERE POWER TRANSISTOR

PNP SILICON 100 VOLTS **200 WATTS** 

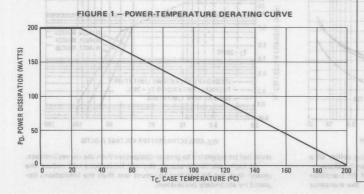


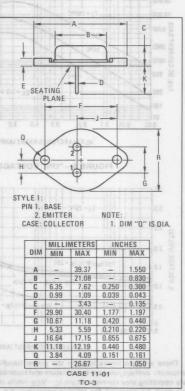
#### **MAXIMUM RATINGS**

		100000	1.053
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCER	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	100	Vdc
Collector-Emitter Voltage	VCEO	90	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	4.0	Vdc
Collector Current	Ic	30	Adc
Base Current	IB	7.5	Adc
Total Device Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	200	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	0.875	oc/W









#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (IC = 200 mAdc, RBE = 100 Ohms)		BVCER	100	-	Vdc
Collector-Emitter Sustaining Voltage (1)		VCEO(sus)	90 9 9	e stelco	MS Vdc
Collector-Base Cutoff Current $(V_{CB} = 100 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 100 \text{ Vdc}, I_E = 0, T_C = 150^{\circ}\text{C})$	d switching ly suited for	olifier OBO <sup>1</sup> saturale one Ampere, Ideal		1.0 5.0	applications a
Emitter-Base Cutoff Current (VBE = 4.0 Vdc, I <sub>C</sub> = 0)	rtings permit	BOST SEBO H	ililgms salu	n bn 1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (IC = 7.5 Adc, VCE = 2.0 Vdc)		Voltage 37d	Sat 25 tion	100 101	• Low Colle VCE(sa
Base-Emitter "On" Voltage (I <sub>C</sub> = 7.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		VBE(on)	Breakdown	1.3 stor-Emitte	ello delle
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>R</sub> = 0.75 Adc)		VCE(sat)	W OGA_bns ,	0.8	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 7.5 Adc, I <sub>B</sub> = 0.75 Adc)		V <sub>BE</sub> (sat)		1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product (IC = 1.0 Adc, VCE = 10 Vdc, f = 1.0 MHz)		fT	2.0	- sol	MHz A H MUMAN
T <sub>J</sub> = 175°C VCE	1111 1	2.0 1.8 1.6	1 b4 1 1	zugu-ette	AGES
T <sub>J</sub> = 175°C	111 401	2.0 1.8 1.6 T <sub>J</sub> = 1.1.2 1.0 V <sub>BE</sub> (sat) ® 0.4 0.2 V <sub>CE</sub> (sat) ® 0.03 0.05 0.1	25°C	1.0 2.0 3	.0 5.0 10
Data shown is obtained from pulse tests and adjusted to nullify effect of ICBO.  IC, COLLECTOR CURRENT (AMP)  FIGURE 4 -	= 2.0 V SEPTION SUPERIOR SUPER	2.0 1.8 1.6 1.2 1.2 1.0 0.8 VBE(sat) @ VBE @ VC 0.4 0.2 VCE(sat) @ 0.03 0.05 0.1	I <sub>C</sub> /I <sub>B</sub> = 10  I <sub>C</sub> /I <sub>B</sub> = 10  I <sub>C</sub> /I <sub>B</sub> = 10  0.2 0.3 0.5  I <sub>C</sub> , COLLECTO	1.0 2.0 3 R CURRENT (A	.0 5.0 10 MP)
Data shown is obtained from pulse tests and adjusted to nullify effect of ICBO.  IC, COLLECTOR CURRENT (AMP)  FIGURE 4 -	= 2.0 V SEPTION SUPERIOR SUPER	2.0 1.8 1.6 1.4 1.2 1.2 1.0 0.08 VBE(sat) @ VBE(sat) @ VBE(sat) @ VBE(sat) @ 0.03 0.05 0.1	Z5°C  IC/IB = 10  IC/IB = 10  O.2 0.3 0.5  IC, COLLECTO  REA  The Safe Optwhich the device load lines for sp. Area to avoid collection below the maximum of the collection of of the colle	1.0 2.0 3 R CURRENT (A	.0 5.0 10 MP)



#### PNP SILICON POWER TRANSISTORS

. . . designed for high-voltage amplifier and saturated switching applications at collector currents to one Ampere. Ideally suited for applications of dc-to-dc converters, relay and hammer drivers, motor controls, and servo and pulse amplifiers. High-voltage ratings permit direct-line operation.

- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = < 1.5 Vdc (Max) @ IC = 500 mAdc</li>
- High Collector-Emitter Breakdown Voltage –
   BVCEO = 200, 300, and 400 Vdc (Min)
- DC Current Gain Specified 10 mAdc to 500 mAdc

1.0 AMPERE
POWER TRANSISTORS
PNP SILICON
200-300-400 VOLTS
5 WATTS

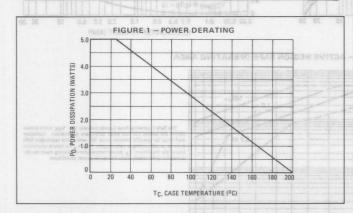


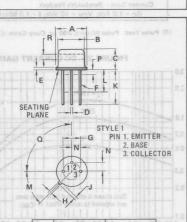
#### MAXIMUM RATINGS

Rating	Symbol	MJ4645	MJ4646	MJ4647	Unit
Collector-Emitter Voltage	VCEO	200	300	400	Vdc
Collector-Base Voltage	VCB	200	300	400	Vdc
Emitter-Base Voltage	VEB		_ 5.0 _	-	Vdc
Collector Current - Continuous Peak	lc lc		- 0.5 - - 1.0 -		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C	PD	5.0		-	Watts
Derate above 25°C			— 28.6 —	3	mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +200	)	°C

#### THERMAL CHARACTERISTICS

THE MINACE CHANACTE MOTION						
Characteristic	Symbol	Max	Unit			
Thermal Resistance, Junction to Case	θЈС	35	°C/W			





	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
Α	8.89	9.40	0.350	0.370
В	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
Н	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70		0.500	-
L	6.35	-	0.250	-
M	450 N	MOI	450 N	MOI
P	-	1.27	-	0.050
0	900 1	MON	900 NOM	
R	2.54	-	0.100	

All JEDEC dimensions and notes apply.

CASE 79-02



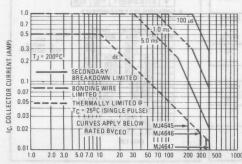


#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Тур	Max	Unit
FF CHARACT	TERISTICS						
Collector-Emitter Breakdown Voltage (1) (IC = 10 mAdc, IB = 0)		MJ4645 MJ4646 MJ4647	BVCEO	200 300 400	ENHOTIMS	1-2/(1 - -	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)		MJ4645 MJ4646 MJ4647	BVCBO	300	IL ICON PO J MJ6503 pa Switching Jo	no SOHBLM'e	Vdc
Emitter-Base B (I <sub>E</sub> = 100 μA	reakdown Voltage dc, I <sub>C</sub> = 0)	witchmodu	BVEBO 90	5.0	particularly a		elji Vdc
Collector Cutoff Current (VCE = 200 Vdc, VBE (off) = 0.5 Vdc)			ICEX	-	- ziotal	age R 10 Hage	μAdc
ON CHARACT	ERISTICS aremeas 0 en/7				elay Drivers	A box biggel	e So
(I <sub>C</sub> = 100 mA	dc, V <sub>CE</sub> = 10 Vdc) dc, V <sub>CE</sub> = 10 Vdc) dc, V <sub>CE</sub> = 10 Vdc) (1)	9	hFE	20 25 20		Nertion Circ	O D
Collector-Emitter Saturation Voltage (IC = 500 mAdc, I <sub>B</sub> = 100 mAdc)		MJ4645 MJ4646 MJ4647	VCE(sat)	Dime © 259 65 to + 200	0.5 0.6 0.75	1.0 1.2 1.5	
OYNAMIC CH	ARACTERISTICS	1		- 736	si marripade at	ansterior 1973 C	001
	Bandwidth Product dc, VCE = 20 Vdc, f = 20 MHz)	MJ4645, MJ4646 MJ4647,	fT	40 30		mit phidoin turation Vol	MHz
Output Capaci (V <sub>CB</sub> = 20 V	tance dc, I <sub>E</sub> = 0, f = 100 kHz)	MJ4645 MJ4646, MJ4647	C <sub>ob</sub>	-	-	80 60	pF
SWITCHING C	HARACTERISTICS					0000000	SALISAN A
Delay Time	(V <sub>CC</sub> = 100 Vdc, I <sub>C</sub> = 500 mAdc,		t <sub>d</sub>	7	7 -	100	ns
Rise Time	I <sub>B1</sub> = 50 mAdc, V <sub>BE(off)</sub> = 5.0 Vdc	)	t <sub>r</sub>	-	4	100	ns
Turn-Off Time	(V <sub>CC</sub> = 100 Vdc, I <sub>C</sub> = 500 mAdc, I <sub>B1</sub> = I <sub>B2</sub> = 50 mAdc, Pulse Width =	1.0 μs)	toff	Symbal QEO(sus)	-	720	ns ins

(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

#### FIGURE 2 - ACTIVE-REGION SAFE OPERATING AREA



VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $\mathbb{I}_{C} - \mathbb{V}_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on  $T_J(pk) = 200^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_J(pk) \leq 200^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### PNP SILICON POWER TRANSISTORS

250 AND 400 VOLTS 125 WATTS

#### Designer's Data for Data "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design.

#### SWITCHMODE SERIES PNP SILICON POWER TRANSISTORS

The MJ6502 and MJ6503 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

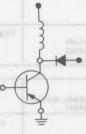
100 ns Inductive Fall Time @ 25°C (Typ) 125 ns Inductive Crossover Time @ 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages Leakage Currents



#### **MAXIMUM RATINGS**

100		192			
		1			
Rating	Symbol	MJ6502	MJ6503	Unit	
Collector-Emitter Voltage	VCEO(sus)	250	400	Vdc	
Collector-Emitter Voltage	VCEV	300	450	Vdc	
Emitter Base Voltage	VEB	6	.0	Vdc	
Collector Current - Continuous Peak (1)	I <sub>CM</sub>		.0	Adc	1
Base Current — Continuous Peak (1)	I <sub>B</sub>		.0	Adc	
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$		7	25 1.5 714	Watts W/°C	
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 t	o +200	°C	

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.4	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	ub TLbdev	275	°C

I. DIMENSIONS Q AND V ARE DATUMS.

2. T. IS SEATING PLANE AND DATUM.
3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:

♦ 0.13 (0.005) M T V M FOR LEADS:

♦ 0.13 (0.005) M T VM QM DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

PIN 1. BASE 2. EMITTER CASE COLLECTOR

1,010	MILLIMETERS		INC	HES	
DIM	MIN	MIN MAX		MAX	
A	-	39.37	-	1.550	
В	1 - 0	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30,15	BSC	1.187 BSC		
G	10.92	BSC	0.430 BSC		
H	5.46	BSC	0.215 BSC		
J	16.89	BSC	0.665 BSC		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	4.83	5.33	0.190	0.210	
V	3.81	4.19	0.150	0.165	

		HILL				131 mgT
	AGE ACC LOS ACCASES					
	1 11/1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				- 3	
			11			
ELECTRICAL CI	HARACTERISTICS (TC = 25°C unless otherwise n	oted)				
ELLCTRICAL CI	Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTE		Symbol	IVIII	Тур	IVIAX	Ome
	Sustaining Voltage (Table 1) MJ6502	V <sub>CEO(sus)</sub>	250			Vdc
(I <sub>C</sub> = 10 mA, I		*CEO(sus)	400	-0.4	20 - 10	0.0
0.0	urrent <sub>MA</sub> ) Tw3HAHII 32A6 gi	ICEV	T (AMPS)	ICTUR OURHEN	1300 al	mAdo
	d Value, V <sub>BE(off)</sub> = 1.5 Vdc)	CLV	_	-	0.5	
	d Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)		STITIS	AUROTOS A	2.5	1913
	urrent partimiledas - a spublia	ICER	- 30	ON VEILTA	3.0	mAdo
	V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100 <sup>o</sup> C)					
Emitter Cutoff Cu		IEBO		-111	1.0	mAdo
(V <sub>EB</sub> = 6.0 Vo						1
	n Collector Current with base forward biased	I <sub>S/b</sub>		See Ei	gure 12	
	e SOA with Base Reverse Biased	RBSOA	See Figure 13			-
ON CHARACTERIS		110001		300 110	,	10
DC Current Gain		hee	15			
(I <sub>C</sub> = 2.0 Adc,	V <sub>CE</sub> = 5 Vdc)		13			
	Saturation Voltage	VCE(sat)	30091-11			Vdc
(IC = 4 Adc, IE		HIN	MIT		1.5	
(IC = 8 Adc, IE	3 = 3.0 Adc) 3 = 1.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)	1 1111	4		5.0	
Base-Emitter Satu		Vest	HE - LY		2.5	Vdc
(IC = 4 Adc, IF	= 1.0 Adc)	VBE(sat)			1.5	vac
	3 = 1.0 Adc, T <sub>C</sub> = 100°C)	90 9.5	ta <u>de</u> el	0.1 (	1.5	7.0
DYNAMIC CHARA				1 - 2 11 11 11 11 11 11 11	and the	
Output Capacitano		Cob	100	-	400	pF
	c, IE = 0, f <sub>test</sub> = 1.0 kHz)		Mornan	agrus gos	221102	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
SWITCHING CHAP						
Resistive Load (Ta				ALTERNA		
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 4.0 A, I <sub>B1</sub> = 1.0 A,	td		0.025	0.1	μs
Rise Time	$t_p = 50 \mu\text{s}$ , Duty Cycle $\leq 2\%$	tr	- 1	0.100	0.5	μs
Storage Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 4.0 A, I <sub>B1</sub> = 1.0 A,	ts	17-1-	0.60	2.0	μς
Fall Time	$V_{BE(off)} = 5 \text{ Vdc}, t_p = 50 \mu s, \text{ Duty Cycle} \leq 2\%$	tf		0.11	0.5	μs
Inductive Load, C	lamped (Table 1)					
Storage Time	(IC = 4 A(pk), VCE(pk) = 250 Vdc, IB1 = 1.0 A,	t <sub>sv</sub>	- 1	0.8	3.0	μs
Crossover Time	VBE(off) = 5 Vdc, Tc = 100°C)	tc	1-1A	0.4	1.5	μs
Fall Time		tfi	1-1-1-3	0.1		μς
Storage Time	(I <sub>C</sub> = 4 A(pk), V <sub>CE</sub> (pk) = 250 Vdc, I <sub>B1</sub> = 1.0 A,	t <sub>sv</sub>		0.5		из из
Crossover Time	V <sub>BE(off)</sub> = 5 Vdc, T <sub>C</sub> = 25°C)	t <sub>C</sub>		0.125		μs
Fall Time VBE(off) = 5 Vdc, TC = 25°C)		tfi		0.1		30 25 µs

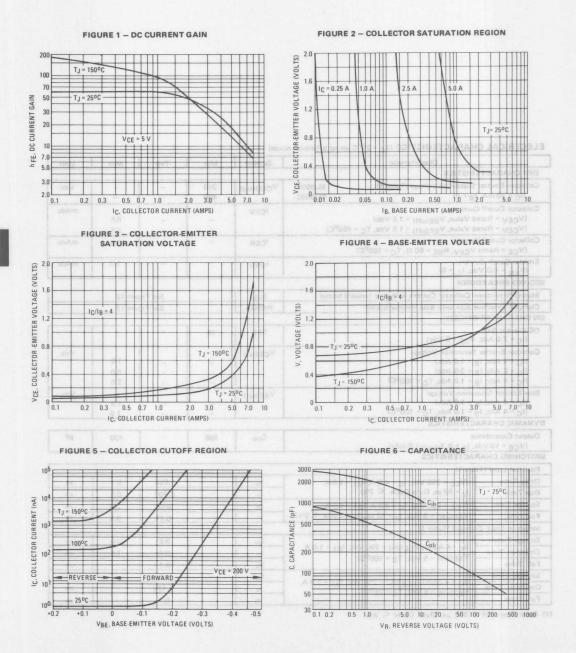


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

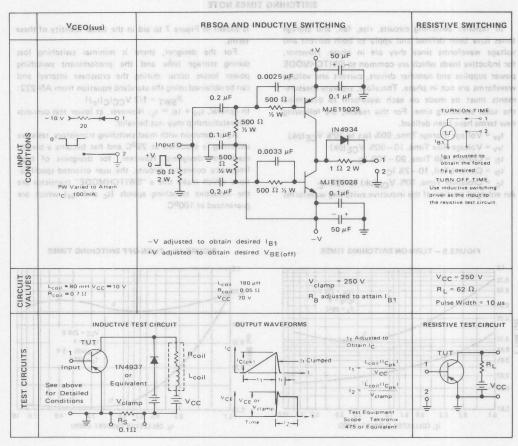


FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS AND FIGURE 8 - INDUCTIVE SWITCHING TIMES

90% IB1 VCE(pk)

VCE\_

IC -

2.7 2.4 VOLTAGE STORAGE TIME 1.5 1.2 0.9 tc 1000C 1c = 4 A 0.8 1c/1g = 4 TJ = 250Ctsv100°C 0.6 CROSSOVER tsv25°C 0.4 0.2 0.6 (HS) tc 25°C 0.3 VBE(off), BASE-EMITTER VOLTAGE (VOLTS)

10% -- IC-

VCE(pk)

#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>CE</sub>(pk)

t<sub>rv</sub> = Voltage Rise Time, 10-90% V<sub>CE</sub>(pk)

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10 - 2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>CE</sub>(pk) to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms

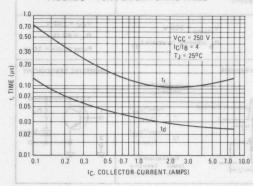
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $P_{SWT} = 1/2 V_{CC} C(t_c) f$ 

In general,  $t_{rv}$  +  $t_{fi}$   $\simeq$   $t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\text{C}}$  and  $t_{\text{SV}}$ ) which are guaranteed at  $100^{\circ}\text{C}$ .





#### FIGURE 10 - TURN-OFF SWITCHING TIMES

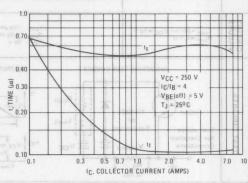
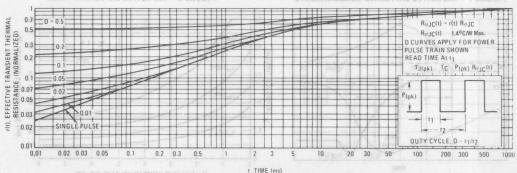


FIGURE 11 - THERMAL RESPONSE

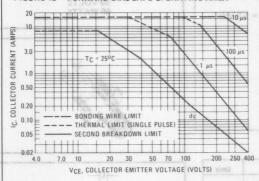


3-766

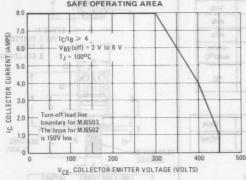


The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

#### FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS DOES SMINE TO BE BEEN TO BE BE

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

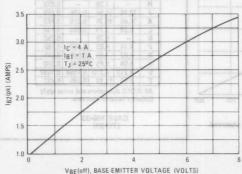
The data of Figure 12 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 15.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

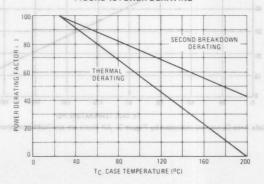
#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the RBSOA characteristics.





#### FIGURE 15 POWER DERATING



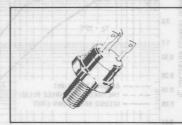
#### MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.2 Vdc (Max) @ IC = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration 700 V Breakdown

#### 7 AMPERE POWER TRANSISTORS PNP SILICON

60 VOLTS 60 WATTS



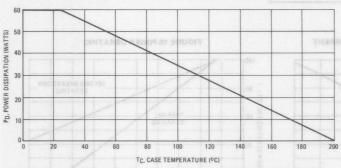
#### **MAXIMUM RATINGS**

culated from Fating and Figure 11:	Symbol	MJ6700	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Base Voltage	VCB	emorter 60	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	Ic.	7.0	Adc
Base Current and appellow agents	baol <sup>1</sup> B/iro	ubri 10 1.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD is	60 343	Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

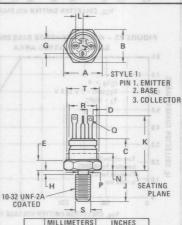
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ples voll θ JC itil	2.91	°C/W

#### FIGURE 1 - POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



	MILLIN	METERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
В	10.77	11.10	0.424	0.437
C	8.13	11.89	0.320	0.468
E	2.29	3.81	0.090	0.150
G	4.70	5.46	0.185	0.215
Н	-	1.98	-	0.078
J	10.16	11.56	0.400	0.455
K	14.48	19.38	0.570	0.763
L	2.29	2.79	0.090	0.110
N	-	6.35	-	0.250
P	4.14	4.80	0.163	0.189
0	1.02	1.65	0.040	0.065
R	8.08	9.65	0.318	0.380
S	4.212	4.310	0.1658	0.1697
T	9.65	11.10	0.380	0.437

All JEDEC dimensions and notes application isolated from case.

CASE 160-03 (TO-59)

#### ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
FF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	60	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 55 Vdc, I <sub>B</sub> = 0)	ICEO	-	100	μAdc
Collector Cutoff Current (VCE = 55 Vdc, VBE(off) = 1.5 Vdc)	O Take IAR ICEX	NER PNP	G4-MUIGE 10	μAdc
	the band amplifier applied on Voltage		1.0	
Collector Cutoff Current (VCB = 60Vdc,IE = 0)	ICBO 3	Vdc (Max)	S.F = (rea)30 10	μAdc
Emitter Cutoff Current (VEB = 5.0 Vdc, IC = 0)	IEBO	est A newes	100	μAdc
N CHARACTERISTICS (1)	Core for Chilled Second	OP OT TOTAL	a Charle of home	de G - O
DC Current Gain (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	hFE	25 25	anotherity 180	μA -

bottmi	Legan Unger	O tol 200 00	AT reser	and in the Con-	Polocia D
		hFE .	25 25 15	180	Α -
VCE(sat)		CE (sat)	_	0.7281417	Vdc
sints	optiv	Leden 2	-	1.2	
Vete	V <sub>E</sub>	BE (sat)		agents V less	Vdc
phy	00	804	1	1.2	and not patte
	sint3 26V	Vote out V	VCE(sat)	hFE 25 25 15 VCE(sat) - VBE(sat)	hFE 25 - 180 - 15 - 1.2 VBE(sat) - 1.2

#### DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (IC = 500 mAdc, VCE = 10 Vdc, f = 10 MHz)	Adc	o fT	30		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	DO/With	C <sub>ob</sub>	-	300	pF
Input Capacitance (VBE = 2.0 Vdc, I <sub>C</sub> = 0, f = 100 kHz)	20	C <sub>ib</sub>		1250	pF

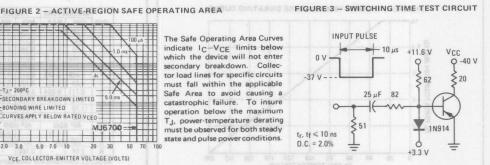
#### SWITCHING CHARACTERISTICS

Delay Time	(V <sub>CC</sub> = 40 Vdc, V <sub>BE(off)</sub> = 4.0 Vdc,		(V <sub>CC</sub> = 40 Vdc, V <sub>BE</sub> (off) = 4.0 Vdc,	dc, t <sub>d</sub>	td	_ 801	100	ns
Rise Time	I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 200 mAdc)	Mak	tr	_ 3	100	ns		
Storage Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc,	17.5	t <sub>s</sub>	486D pt -	1.0	μѕ		
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 200 mAdc)		tf	_	150	'ns		

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2.0%

## COLLECTOR CURRENT SECONDARY BREAKDOWN LIMITED 0.1 --- BONDING WIRE LIMITED 0.05 CURVES APPLY BELOW RATED VCEO MJ6700 --2.0 3.0 5.0 7.0 10 VCE. COLLECTOR-EMITTER VOLTAGE (VOLTS)

The Safe Operating Area Curves indicate IC-VCE limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.





#### MEDIUM-POWER PNP SILICON TRANSISTORS

.... designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 1.2 Vdc (Max) @ IC = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

#### 5 AMPERE POWER TRANSISTORS

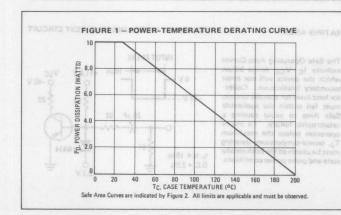
60 VOLTS 10 WATTS

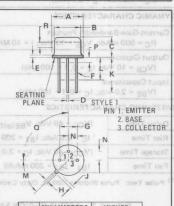
#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	760138V 60	Vdc
Collector-Base Voltage	VCB	60	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	Ic	5.0	Adc
Base Current	1 <sub>B</sub>	1.0	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	10 57.2	Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	17.5	°C/W

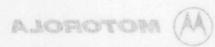




(I c = 2.0 Adc.

	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
В	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
Н	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	DETERMINE	0.500	NOS
L	6.35	WOLLIN:	0.250	WILL S
M	450 N	MOI	450 N	OM
P	-	1.27		0.050
0	90° N	MOI	900 N	OM.
R	2.54	-	0.100	-

All JEDEC dimensions and notes apply. CASE 79-02 TO-39



# MJ8501

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

	Characteristic			Symbol	Min	Max	Unit
OFF CHARACTER	RISTICS						
Collector-Emitte	er Sustaining Voltage (1) dc, I <sub>B</sub> = 0)			VCEO(sus)	60	2) (, = 3) ()	Vdc
				ICEO	WITCHMO	100	μAdc
Collector Cutof	f Current /dc, VBE(off) = 1.5 Vdc)		r Unsa lesigned for high		DEBLM bas		μAdc
(V <sub>CE</sub> = 55 \	/dc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 15	0 0,	or cuits where to re operated swit			high on the	mAdc
Collector Cutof (V <sub>CB</sub> = 60 \	f Current /, I <sub>E</sub> = 0)			СВО	28 75	10	μAdc
Emitter Cutoff (VBE = 5.0				IEBO	_	100	μAdc
ON CHARACTER	ISTICS (1) and anim				A mariana	sign uns uron	DIGC B
(IC = 2.0 Ac	n Adc, V <sub>CE</sub> = 2.0 Vdc) ic, V <sub>CE</sub> = 2.0 Vdc) ic, V <sub>CE</sub> = 2.0 Vdc)			hFE	25 25 15	180 mo	Past Tu 300
Collector-Emitt	er Saturation Voltage dc, I <sub>B</sub> = 0.2 Adc) dc, I <sub>B</sub> = 0.5 Adc)		(0)	VCE(sat)	Crossover Till Stor <del>s</del> ge Time	0.7	00eVdc 00e
Base-Emitter Sa (I <sub>C</sub> = 2.0 Ac	uturation Voltage dc, I <sub>B</sub> = 0.2 Adc) dc, I <sub>B</sub> = 0.5 Adc)			V <sub>BE</sub> (sat)	on Rungs of Specified for OA with Inde	1.2	Vdc
DYNAMIC CHAR	ACTERISTICS			Foeds	ענה והפטבנועם	sawii Sullua	TIWA
	Bandwidth Product dc, VCE = 10 Vdc, f = 10 MHz)			fT	30	ege Currents	MHz
Output Capacit	ance /dc, l <sub>E</sub> = 0, f = 100 kHz)			C <sub>ob</sub>		300	pF
Input Capacitar	vdc, I <sub>C</sub> = 0, f = 100 kHz)			C <sub>ib</sub>		1250	pF
SWITCHING CHA							
Delay Time	(V <sub>CC</sub> = 40 Vdc, V <sub>BE</sub> (off) = 4.0	Vdc vinU	1 0385FE 0	t <sub>d</sub>	8	100	ns
Rise Time	I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 0.2 Adc)	obV_		t <sub>r</sub>	loV.	100	ns
Storage Time	(V <sub>CC</sub> = 40 Vdc, I <sub>C</sub> = 2.0 Adc,	Vete	1400	t <sub>s</sub>	-	1.0	μs
Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 0.2 Adc)			as tf of	- 1	150	ecuso Curra
FIGUR  10 5.0 2.0 1.0 0.5 TJ + 200°C 0.2 Seco 0.1	Lise Width ≤ 300 μs, Duty Cycle  E 2 — ACTIVE-REGION SAFE C  100 μs  100 μs  100 ms  10 ms	The Safe indicate which the secondar tor load must fal Safe Ar catastropoperatio	e Operating Area IC-VCE limits the device will not preakdown. (lines for specific coll within the ago ea to avoid cauchic failure. To no below the man er-temperature de	Curves below tenter Collec- ircuits licable -37 V sing a insure cimum crating	INPUT PULSE		VCC 9-40
0.02 Puls	e Duty Cycle ≤ 10%	must be	observed for both I pulse power cond	steady	10 ns \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	+3.3 V	IN914

The MJ8500 and MJ8501 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

300 ns Inductive Fall Time - 25°C (Typ) 500 ns Inductive Crossover Time - 25°C (Typ) 900 ns Inductive Storage Time - 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

**MAXIMUM RATINGS** 

0821				
Rating	Symbol	MJ8500	MJ8501	Unit
Collector-Emitter Voltage	VCEO(sus)	700	800	Vdc
Collector-Emitter Voltage	VCEV	1200	1400	Vdc
Emitter Base Voltage	VEB	8.0	8.0	Vdc
Collector Current — Continuous Peak (1)	I <sub>C</sub>	2.5 5.0	2.5 5.0	Adc
Base Current — Continuous Peak (1)	I <sub>B</sub>	2.0 4.0	2.0 4.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD N	125 71 0.71	125 71 0.71	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.4	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	montisan	275	°C

2.5 AMPERE

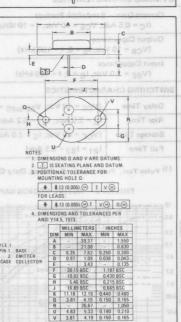
#### NPN SILICON POWER TRANSISTORS

700 and 800 VOLTS 125 WATTS

> Designer's Data for "Worst Case" Conditions

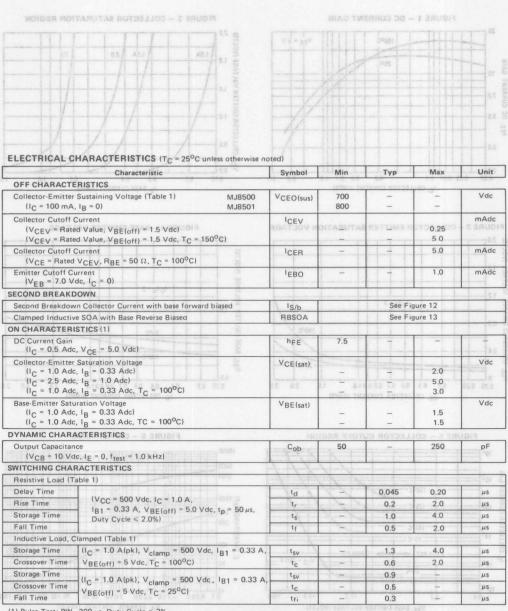
The Designers' Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case"





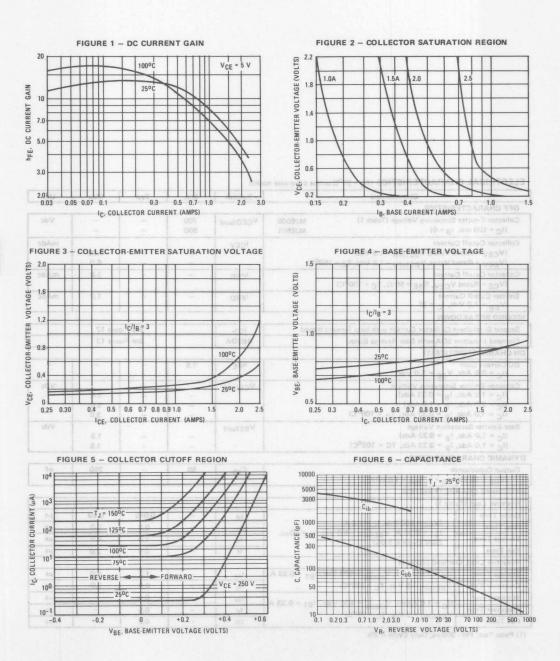
CASE 1-05 TO-3

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



<sup>(1)</sup> Pulse Test: PW - 300  $\mu$ s, Duty Cycle  $\leq$  2%.





#### ROMANAOWARD DIMANYO HOR PROTECTION OF TANITCHING TIMES NOTE

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

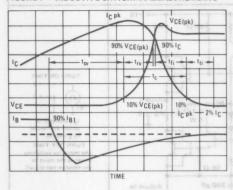
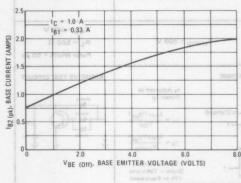


FIGURE 8 - PEAK REVERSE BASE CURRENT



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% VCE (pk)

try = Voltage Rise Time, 10-90% VCE (pk)

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>CE</sub> (pk) to 10% I<sub>C</sub> An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

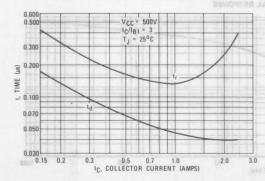
 $P_{SWT} = 1/2 \; V_{CC} I_{C}(t_{c}) \, f$  In general,  $t_{rv} + t_{fi} \simeq t_{c}.$  However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

#### RESISTIVE SWITCHING PERFORMANCE

FIGURE 9 - TURN - ON SWITCHING TIMES





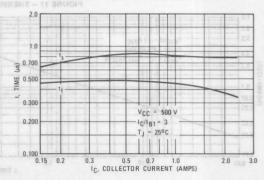
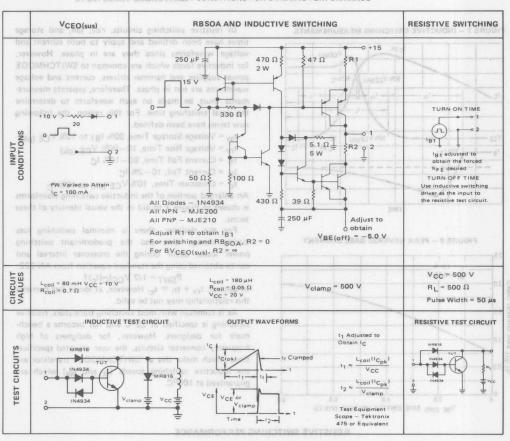
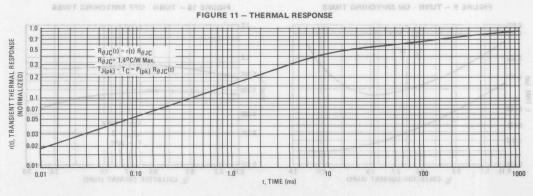


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE







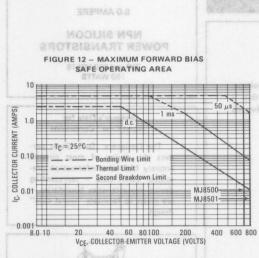
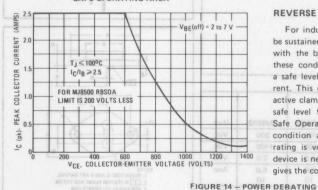


FIGURE 13 - RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



CASE 1:05 TO-3

#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

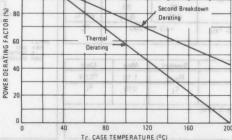
TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.

Purposes: 178" from Cast for S. Secon







#### Designers Data Sheet

## SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJ8502 and MJ8503 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators avisto and nortequesib rate app
- Inverters = OT no beed on 12 is been and
- Solenoid and Relay Drivers
- Motor Controls and become 2025 & all name between
- Deflection Circuits

Fast Turn-Off Times Two owork and the Institute

150 ns Inductive Fall Time—25°C (Typ)

400 ns Inductive Crossover Time-25°C (Typ)

1200 ns Inductive Storage Time-25°C (Typ)

Operating Temperature Range -65 to + 200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads

Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

#### MAXIMUM RATINGS

, () (11)	THE PERSON NAMED IN COLUMN	ACTIVATION TO THE REAL PROPERTY.	CC-100-1	
ng, load line shaping, etc. The sis specified as Reverse Blas represents the gnitsRe-current		and the same of		Unit
Collector-Emitter Voltage and Service	VCEO(sus)	700	800	Vdc
Collector-Emitter Voltage	VCEV b	1200	1400	Vdc
Emitter Base Voltage an adams leve no	VEB	9.8.0	8.0	Vdc
Collector Current - Continuous Peak (1)	I <sub>CM</sub>	5.0 10	5.0 10	Adc
Base Current - Continuous Peak (1)	I <sub>B</sub>	4.0 8.0	4.0 8.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above 25°C	PD	150 86 0.85	150 86 0.85	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	0+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.16	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

#### 5.0 AMPERE

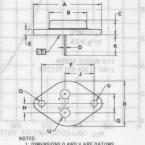
## NPN SILICON POWER TRANSISTORS

700 and 800 VOLTS 150 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers' Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.





- 1. DIMENSIONS Q AND V ARE DATUMS.
  2. T. IS SEATING PLANE AND DATUM.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
- MOUNTING HOLE Q:
- ♦ ♦.13 (0.005) ⋈ T V ⋈ FOR LEADS:
- ♦ 13 (0.005) ⊗ T V ⊗ Q ⊗

  4. DIMENSIONS AND TOLERANCES PER
- ANSI Y14.5, 1973.

			MILLIN	METERS	INCHES	
	LET CO Z	DIM	MIN	MAX	MIN	MAX
YLE 1		A	-	39.37	-	1.550
PIN 1.		В	-	21,08	-	0.830
2		C	6.35	7,62	0.250	0,300
CASE		D	0.97	1.09	0.038	0.043
MODER DES	E	-	3.43	-	0.135	
	F	30,15	BSC	1,187 BSC		
		G	10.92	BSC	0.430 BSC	
		H	5.46 BSC		0.215 BSC	
		J	16.89 BSC		0.665 BSC	
	K	11.18	12,19	0.440	0.480	
	Q	3.81	4.19	0.150	0.165	
		R	-	26.67	-	1,050
		U	4.83	5.33	0.190	0.210
		V	3.81	4.19	0.150	0.165

CASE 1-05 TO-3

FIGURE 2 - COLLECTOR SATURATION REGION			FIGURE 1 - DC CURRENT GAIN					
					39000 - 23	-		
					-			
	1 8							
	171 5							
IARACTERISTICS (TC = 25°C u	nless otherwise n	noted)	+++					
Characteristic	. 9	Symbol	Min	Тур	Max	Unit		
RISTICS	6.0	Total Control	A STATE OF THE PARTY OF THE PAR	VA 80 1	D CO	2.0 10.0 2		
Sustaining Voltage (Table 1)	MJ8502	VCEO(sus)	700	MARRUZ ROYS	1300 7	Vdc		
	MJ8503	020(303)	800	-	-			
urrent		ICEV	78.6.			mAdd		
Value, VBE(off) = 1.5 Vdc)			_	-	0.25			
Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_{C} = 19$	50°C)	MOIDSH	MCH LANU	MAZRETTIME	5.0	10 - 8 35		
	TTT ALL	ICER	-	HITTI	5.0	mAdd		
		-						
		IEBO		THE T	1.0	mAdd		
	111 2		-			1111		
Collector Current with base forward	d biased	I IS/b		See Fi	gure 12			
Clamped Inductive SOA with Base Reverse Biased		RBSOA		See Fi	gure 13			
TICS (1)	LIDA F							
		T hee T	7.5		H-1			
VCE = 5.0 Vdc)		10000	-					
Saturation Voltage	HH I	VCE(sat)			Heleli	Vdc		
		3085	3		2.0	(tell 10V)		
		I TT	-	Triber -	5.0			
	A0.0	1	-	10 00	3.0	1.0		
		VBE(sat)	(90A) TV	GERED ROTOE	(00 -01	Vdc		
					10000			
		1			1			
		I Cab	60	CTOIL CUT	300	U opF		
		-00				P.		
	- Professor	N 7-3	DC IX					
ble 1)			XV	V				
	2000	t <sub>d</sub>	7-7	0.040	0.20	μς		
	50	t <sub>r</sub>	1-1	0.125	2.0	μs		
	$t_p = 50 \mu s$ ,		Palls.	1.2	4.0	μs		
Daty Cycle & 2.0%)	1003 13	tf		0.65	2.0	μs		
			U 15		3/901			
amped (Table 1)								
	Ins = 1.0 A	teu	1 -1 -	1.6	5.0	μs		
(IC = 2.5 A(pk), V <sub>clamp</sub> = 500 Vdc	, I <sub>B1</sub> = 1.0 A,	t <sub>sv</sub>	1			-		
(I <sub>C</sub> = 2.5 A(pk), V <sub>clamp</sub> = 500 Vdc VBE(off) = 5 Vdc, TC = 100°C)		t <sub>c</sub>	\ -  ·	0.60	5.0	μs		
(IC = 2.5 A(pk), V <sub>clamp</sub> = 500 Vdc			) - I			-		
	Characteristic  RISTICS  RISTICS  Sustaining Voltage (Table 1)  IB = 0)  urrent  I Value, VBE(off) = 1.5 Vdc)  I Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 19  urrent  VCEV, RBE = 50 Ω, T <sub>C</sub> = 100°C)  rrent  C, I <sub>C</sub> = 0)  DWN  Collector Current with base forward  SOA with Base Reverse Biased  STICS (1)  VCE = 5.0 Vdc)  Saturation Voltage  IB = 1.0 Adc, T <sub>C</sub> = 100°C)  ation Voltage  IB = 1.0 Adc, T <sub>C</sub> = 100°C)  CTERISTICS  CTERISTICS  SEC., I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)  ACTERISTICS  Ble 1)  (V <sub>CC</sub> = 500 Vdc, IC = 2.5A,	Characteristic  RISTICS  Sustaining Voltage (Table 1)  MJ8502  MJ8503  Urrent  d Value, VBE(off) = 1.5 Vdc)  3 Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)  Urrent  VCEV, RBE = 50 Ω, T <sub>C</sub> = 100°C)  Trent  C, I <sub>C</sub> = 0)  Collector Current with base forward biased  SOA with Base Reverse Biased  STICS (1)  VCE = 5.0 Vdc)  Saturation Voltage  B = 1.0 Adc, T <sub>C</sub> = 100°C)  CTERISTICS  Be  C, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)  ACTERISTICS  ble 1)  (V <sub>CC</sub> = 500 Vdc, I <sub>C</sub> = 2.5A,  I <sub>B</sub> = 1.0 A, V <sub>B</sub> E(off) = 5.0 Vdc, t <sub>p</sub> = 50 μs,  I <sub>B</sub> = 1.0 A, V <sub>B</sub> E(off) = 5.0 Vdc, t <sub>p</sub> = 50 μs,	Characteristic   Symbol	Characteristic   Symbol   Min	Characteristic   Symbol   Min   Typ	ARACTERISTICS (T <sub>C</sub> = 25°C unless otherwise noted)   Characteristic   Symbol   Min   Typ   Max		



IC. COLLECTOR CURRENT (µA)

101

100

10-1

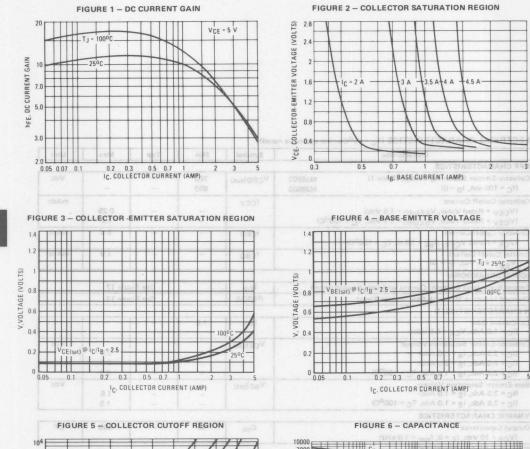
TJ = 150°C

125°C:

75°C

25°C

VBE, BASE-EMITTER VOLTAGE (VOLTS)



CAPACITANCE (pF)

VR, REVERSE VOLTAGE (VOLTS)

VCE = 250 V -

+0.6

#### SWITCHING TIMES NOTE

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

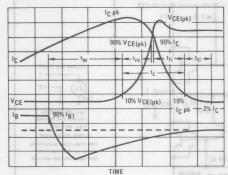
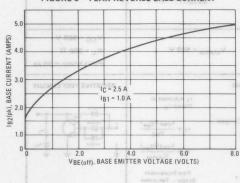


FIGURE 8 - PEAK REVERSE BASE CURRENT



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% VCE(pk)

try = Voltage Rise Time, 10-90% VCE(pk)

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% VCE(pk) to 10% IC

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $\begin{array}{c} P_{SWT} = 1/2~V_{CC} I_{C}(t_{c}) f \\ \text{In general, } t_{rv} + t_{fi} \cong t_{c}. ~\text{However, at lower test currents} \end{array}$ 

this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.

#### RESISTIVE SWITCHING PERFORMANCE

FIGURE 9 - TURN-ON SWITCHING TIMES

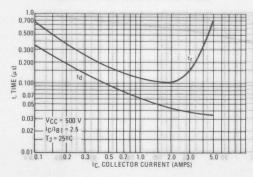


FIGURE 10 - TURN-OFF SWITCHING TIMES

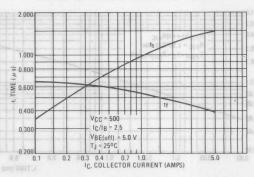
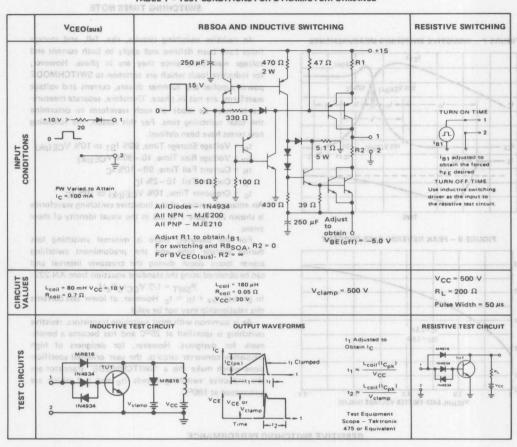
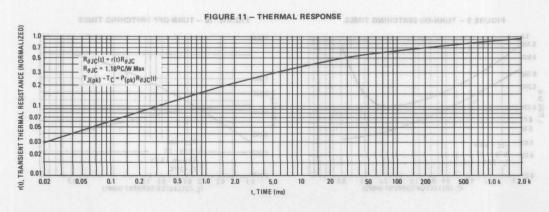
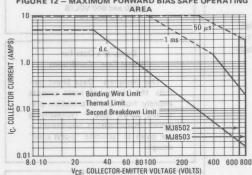


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

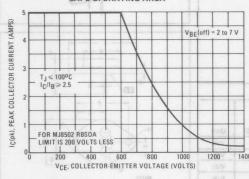




MOTOROLA



#### FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

### FORWARD BIAS HENOS MODILIE WAN

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

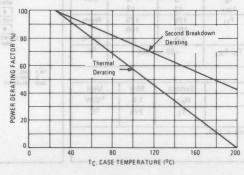
The data of Figure 12 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J(pk)</sub> may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS I eviroubel driv AO2 basel8-serevoR

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.





# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJ8504 and MJ8505 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switch-mode applications such as:

- Switching Regulators
   Switching Regulators
- Inverters and level rework no onlinearsh elders
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times of person and analysis general seaso was as

75 ns Inductive Fall Time –25°C (typ)
150 ns Inductive Crossover Time –25°C (typ)

1.25 μs Inductive Storage Time –25°C (typ)

Operating Temperature Range -65 to + 200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads
Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

MAXIMUM RATINGS

is specified as Reverse Blas epresents the voltage current		level for	etar -	
Rating	Symbol	MJ8504	MJ8505	Unit
Collector-Emitter Voltage	VCEO(sus)	700	800	Vdc
Collector-Emitter Voltage	VCEV	1200	1400	Vdc
Emitter Base Voltage	VEB	8.0	8.0	Vdc
Collector Current - Continuous Peak (1)	I <sub>C</sub>	10 15	10 15	Adc
Base Current — Continuous Peak (1)	I <sub>B</sub>	8 12	8 12	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	175 100 1.0	175 100 1.0	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°c

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

10 AMPERE

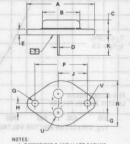
#### NPN SILICON POWER TRANSISTORS

700 and 800 VOLTS 175 WATTS

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.





- 1. DIMENSIONS Q AND V ARE DATUMS.
  2. \_\_T\_ IS SEATING PLANE AND DATUM.
  3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
- ♦ 13 (0.005) ⊗ T V ⊗ Q ⊗
  4. DIMENSIONS AND TOLERANCES PER
  ANSI Y14.5, 1973.

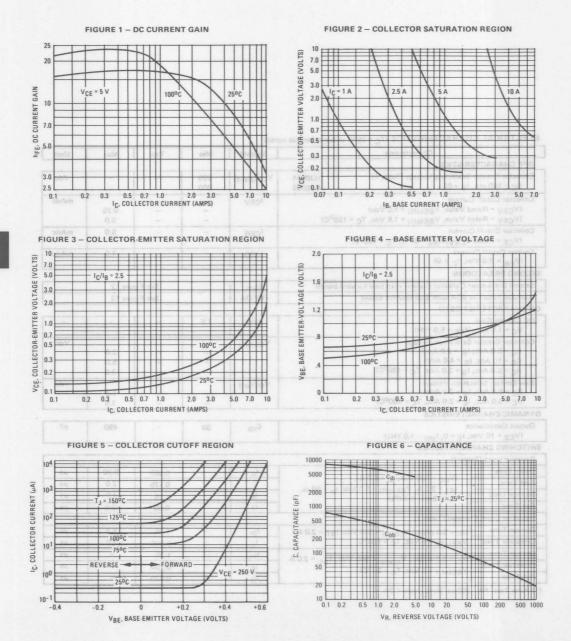
STYLE 1
PIN 1. BASE
2. EMITTER
CASE COLLECTOR



CASE 1-05 TO-3

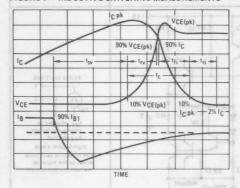
FIGURE 2 - COLLECTOR SATURATION REDION					
	more				
AND					
ELECTRICAL CHARACTERISTICS (T <sub>C</sub> = 25°C unless otherwise no	oted)				
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	THE PLANT				
Collector-Emitter Sustaining Voltage (Table 1) MJ8504	VCEO(sus)	700		11-1-	Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0) MJ8505	ELLLI	800	- 4111	10-1-	
Collector Cutoff Current	ICEV	(098(A) TH)	ABUS ROTOS.	100.01	mAdc
$(V_{CEV} = Rated Value, V_{BE(off)} = 1.5 \text{ Vdc})$		To the		0.25 5.0	
(V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	1			5.0	mAdc
Collector Cutoff Current ( $V_{CE}$ = Rated $V_{CEV}$ , $R_{BE}$ = 50 $\Omega$ , $T_{C}$ = 100°C)	CER	MOLTASUTA	EMITTER S	5.0	- S 3 AU
Emitter Cutoff Current	IEBO			1.0	mAdc
(V <sub>EB</sub> = 7.0 Vdc, I <sub>C</sub> = 0)	.580				
ECOND BREAKDOWN				101g = 2.5 -	
Second Breakdown Collector Current with base forward biased	Is/b		See Fig	ure 12	
Clamped Inductive SOA with Base Reverse Biased	RBSOA	See Figure 13			
ON CHARACTERISTICS (1)	111111				
DC Current Gain	PEE	7.5			
(I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 5.0 Vdc)	EBACK!				
Collector-Emitter Saturation Voltage	VCE(sat)	No 08801			Vdc
$(I_C = 5.0 \text{ Adc}, I_B = 2.0 \text{ Adc})$				2.0 5.0	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 4.0 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 2.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)				3.0	
Base-Emitter Saturation Voltage	V <sub>BE</sub> (sat)	ales des		0.0	Vdc
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 2.0 Adc)	VBE(sat)	1		1.5	less beautiful
$(I_C = 5.0 \text{ Adc}, I_B = 2.0 \text{ Adc}, T_C = 100^{\circ}\text{C})$	01 0.1 0.1	2.0 3.0	0.1 1.0	1.5	0 13
DYNAMIC CHARACTERISTICS		50 1009/-10	namente mures	1,1000.31	
Output Capacitance	Cob	90	-	450	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)					
SWITCHING CHARACTERISTICS	×	IDIUSH HAD	UD RUTUS.	1767 - 636	DOM
Resistive Load (Table 1)	program.				
Delay Time (V <sub>CC</sub> = 500 Vdc, I <sub>C</sub> = 5.0 A,	t <sub>d</sub>	1	0.050	0.20	μs
In 1 = 2.0 A. VRE (off) = 5.0 Vdc. to = 50 us.	tr	1 3 3	0.175	2.0	μs
Storage Time Duty Cycle ≤ 2.0%)	ts	d Adam	1.25	4.0	μs
Fall Time	tf	A-36-3	0.60	2.0	μs
Inductive Load, Clamped (Table 1)			Thomas		
Storage Time (I <sub>C</sub> = 5.0 A(pk), V <sub>clamp</sub> = 500 Vdc, I <sub>B1</sub> = 2.0 A,	t <sub>sv</sub>	-\	1.75	5.5	μs
Crossover Time V <sub>BE(off)</sub> = 5 Vdc. T <sub>C</sub> = 100 <sup>o</sup> C	t <sub>c</sub>		0.400	2.0	μs
Storage Time $(I_C = 5.0 \text{ A}(pk), V_{clamp} = 500 \text{ Vdc}, I_{B1} = 2.0 \text{ A},$	tsv	A	1.25		μs
VBE(off) = 5 Vdc, Tc = 25°C)	t <sub>c</sub>	+ V = 0 000	0.150	ese- 3213V59	μs
Fall Time	tfi		0.075		μs



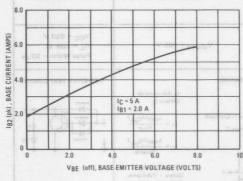


#### SOME SALE SOURCE COMPLETE CONTRIBUTIONS FOR DAWNING LINES NOTE

#### FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



#### FIGURE 8 - PEAK REVERSE BASE CURRENT



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% IB1 to 10% VCE(pk)

try = Voltage Rise Time, 10-90% VCE(pk)

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% VCE(pk) to 10% IC

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

$$\begin{split} P_{SWT} = 1/2 \ V_{CC} I_{C}(t_{c}) \, f \\ \text{In general, } t_{rv} + t_{fi} & \simeq t_{c}. \ \text{However, at lower test currents} \\ \text{this relationship may not be valid.} \end{split}$$

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $\{t_{\text{C}} \text{ and } t_{\text{SV}}\}$  which are guaranteed at  $100^{\circ}\text{C}$ .

#### RESISTIVE SWITCHING PERFORMANCE

FIGURE 9 - TURN-ON SWITCHING TIMES

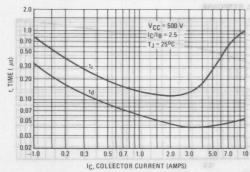
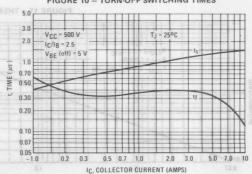
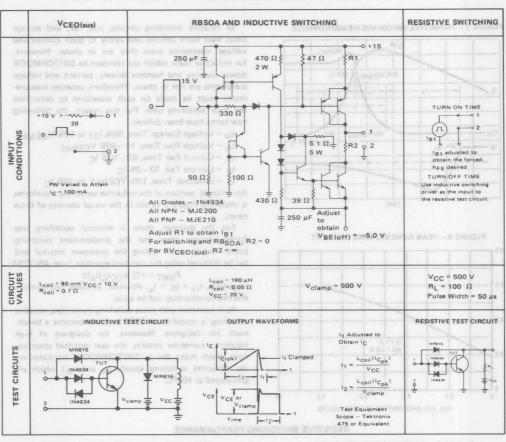


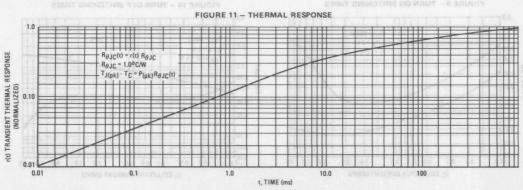
FIGURE 10 - TURN-OFF SWITCHING TIMES



3

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE







## AND REWORD SAFE OPERATING AREA INFORMATION

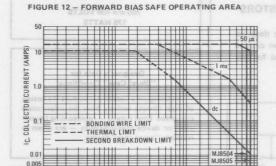
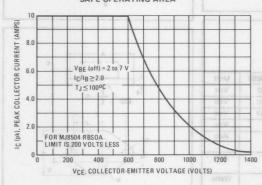


FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA

VCE, COLLECTOR EMITTER VOLTAGE (VOLTS)



### FORWARD BIAS LIRAG REWOR MOOLLING MINI

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

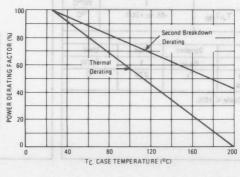
The data of Figure 12 is based on  $T_C=25^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias. Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.

FIGURE 14 - POWER DERATING







### Designer's Data Sheet

#### SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS

The MJ10000 and MJ10001 darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switch-mode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

100°C Performance Specified for: Reversed Biased SOA with Inductive Loads ≈100 Switching Times With Inductive Loads — 210 ns Inductive Fall Time (Typ) Saturation Voltages Leakage Currents



#### **POWER DARLINGTON TRANSISTORS**

350 and 400 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves - representing boundaries on device characteristics - are given to facilitate "worst case" design.

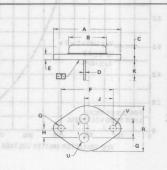


-183 1010all Rating 1864 priloage	Symbol	MJ10000	MJ10001	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	450	500	Vdc
Emitter Base Voltage	VEB	Hitshan Or elt	3	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub> M		0	Adc
Base Current — Continuous — Peak (1)	IBM	STATE OF THE REAL	.5 5	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	- LU GUDAN - 1906	75 00 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1	°C/W
Maximum Lead Temperature for Soldering	TL	275	оС
Purposes: 1/8" from Case for 5 Seconds		1	

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



	MILLIA	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	-	1.550
В		21.08	-	0.830
C	6.35	7,62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	1.40	1.78	0.055	0.070
F	30.15 BSC		1.187 BSC	
G	10.92 BSC		0,430 BSC	
Н	5.46 BSC		0.215 BSC	
1	16.89 BSC		0.66	BSC
K	11.18	12.19	0.440	0.480
0	3.81	4.19	0.150	0.165
R	-	26.67	-	1,050
U	4.83	5.33	0.190	0.210
٧	3.81	4.19	0.150	0.165

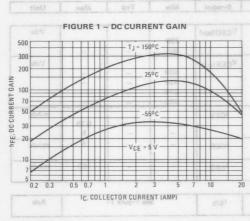
**CASE 1-05** TO-204AA

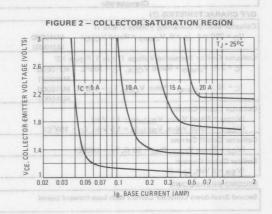
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (2)	7.1-1-1				
Collector-Emitter Sustaining Voltage (Table 1)	V <sub>CEO(sus)</sub>	WIND IN	וייי ביונואן	P I SHUDIN	Vdc
(I <sub>C</sub> = 250 mA, I <sub>B</sub> = 0, V <sub>clamp</sub> = Rated V <sub>CEO</sub> ) MJ10000	CEO (303)	350			1 7000
MJ10001		400	Mi ali		
Collector-Emitter Sustaining Voltage (Table 1, Figure 12)	VCEX(sus)				Vdc
I <sub>C</sub> = 2 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C MJ10000		400	5 -	DN-L	1003
MJ10001	/ 14	450	-		007
I <sub>C</sub> = 10 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C MJ10000		275 325			70
MJ10001	Town 1	323	,		mAdc
Collector Cutoff Current (VCEV = Rated Value, VBE(off) = 1.5 Vdc)	CEV			0.25	MAGC
(VCEV = Rated Value, VBE(off) = 1.5 Vdc, TC = 150°C)		_		5	
Collector Cutoff Current	ICER			5	mAdc
(V <sub>CE</sub> = Rated V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100 <sup>o</sup> C)	CLI		- 30"	HELL	V In
Emitter Cutoff Current	IEBO			150	mAdc
(V <sub>EB</sub> = 8 Vdc, I <sub>C</sub> = 0)					
SECOND BREAKDOWN 3.0 10 10 10 10 10 10 10 10 10 10 10 10 10					
Second Breakdown Collector Current with base forward biased	Is/b	(98iA) T	See Figure 1	13,00,31	Adc
ON CHARACTERISTICS (2)					
DC Current Gain YLOV RETTIME BOAR - A BAUDIA	hFE		HE YTHAME	ROTOBLIO	SURE3 C
(I <sub>C</sub> = 5 Adc, V <sub>CE</sub> = 5 Vdc)	e c iti	50	-	600	
(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 5 Vdc)		40	-	400	
Collector-Emitter Saturation Voltage	VCE(sat)				Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 400 mAdc)	11			1.9	
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 1 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 400 mAdc, T <sub>C</sub> = 100°C)				2	
Base-Emitter Saturation Voltage	V <sub>BE</sub> (sat)				Vdc
(IC = 10 Adc, IB = 400 mAdc)	*BE(sat)			2.5	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 400 mAdc, T <sub>C</sub> = 100°C)		N-1	93 - TI	2.5	L SI
Diode Forward Voltage (1)	Vf		3	5	Vdc
(I <sub>F</sub> = 10 Adc)		N 30			
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain	Ihfel	10			
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1 MHz)					
Output Capacitance	Cob	100		325	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)		(986) (1	BREUD BOYO	19.103.34	
SWITCHING CHARACTERISTICS					
Resistive Load (Table 1)					
Delay Time BOMATIOA9A1 YUSTUO - A BRUDIA	t <sub>d</sub>	PERLITOR	0.12	0.2	μѕ
(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A,	tr		0.20	0.6	μѕ
I <sub>B1</sub> = 400 mA, V <sub>BE</sub> (off) = 5 Vdc, t <sub>p</sub> = 50 $\mu$ s, Storage Time Duty Cycle $\leq$ 2%).	ts		1.5	3.5	μѕ
Fall Time	t <sub>f</sub>	2	1.1	2.4	μs
Inductive Load, Clamped (Table 1)		7/1/2		2.7	-
	t <sub>sv</sub>	11	3.5	5.5	μs
Storage Time $(I_C = 10 \text{ A(pk)}, V_{clamp} = \text{Rated } V_{CEX}, I_{B1} = 400 \text{ mA},$ Crossover Time $V_{BE(off)} = 5 \text{ Vdc}, T_C = 100^{\circ}\text{C})$	t <sub>c</sub>	-1	1.5	3.7	us us
			7796	3.7	
Storage Time $(I_C = 10 \text{ A(pk)}, V_{clamp} = \text{Rated } V_{CEX}, I_{B1} = 400 \text{ mA},$ Crossover Time $V_{RE(off)} = 5 \text{ Vdc}, T_C = 25^{\circ}\text{C})$	t <sub>sv</sub>	1-1	1.0	- anax	μs
Crossover Time V <sub>BE(off)</sub> = 5 Vdc, T <sub>C</sub> = 25°C)	tc	-	0.7	-	μs

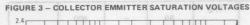
recovery rectifiers.

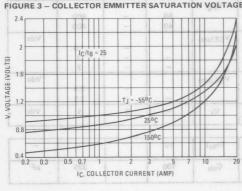
Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast

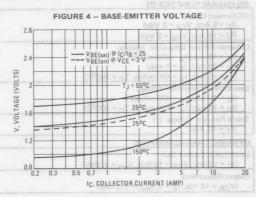




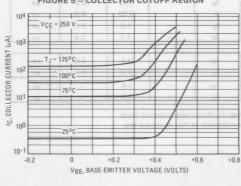


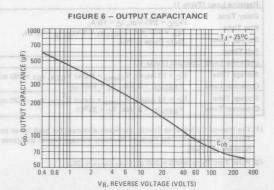






# FIGURE 5 - COLLECTOR CUTOFF REGION





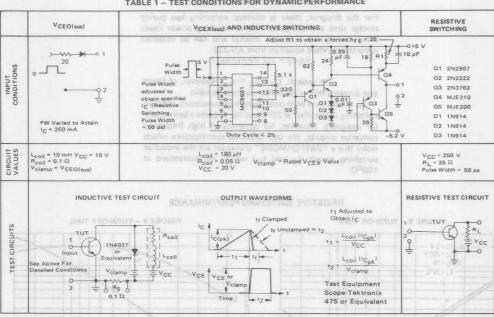
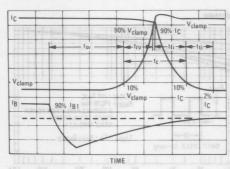


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

#### FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

SWITCHING TIMES NOTE

t<sub>sv</sub> = Voltage Storage Time, 90% IB1 to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 7 to aid in the visual identity of these terms.

#### SWITCHING TIMES NOTE (continued)

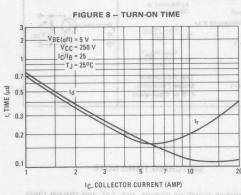
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

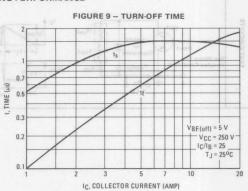
PSWT = 1/2 VCCIC(tc) f

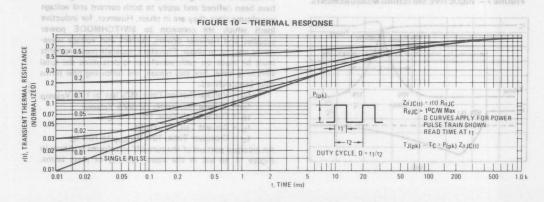
In general,  $t_{rv} + t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\rm o}{\rm C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at  $100^{\rm o}{\rm C}$ .

#### RESISTIVE SWITCHING PERFORMANCE



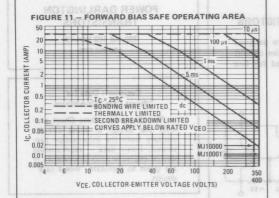




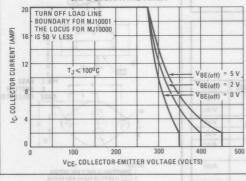
3



The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.



#### FIGURE 12 – REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

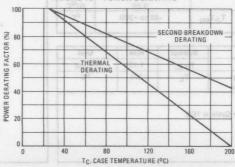
The data of Figure 11 is based on  $T_C=25^{o}C\colon T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

TJ(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as VCEX(sus) at a given collector current and represents a voltage-current condition that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete reverse bias safe operating area characteristics.







### Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS

The MJ10002 and MJ10003 darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switch-mode applications such as:

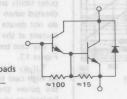
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads
Switching Times with Inductive Loads —

140 ns Inductive Fall Time (Typ)

Saturation Voltages Leakage Currents



#### MAXIMUM RATINGS

MAXIMOM PATIMOS		36 10 1190 21		HIDWHIN
elga adT Rating in arte and bea	Symbol	MJ10002	MJ10003	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	450	500	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub> M		0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		.5	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	DRETAIL	50 00 .86	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	o +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

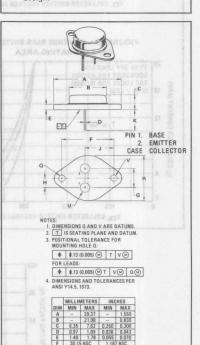
# 10 AMPERE NPN SILICON

#### POWER DARLINGTON TRANSISTORS

350 and 400 VOLTS 150 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design



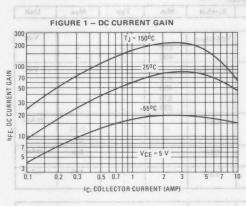
CASE 1-05 TO-204AA

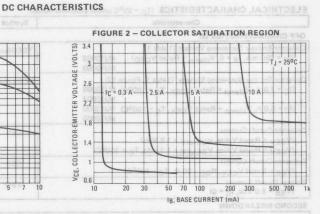
3-796

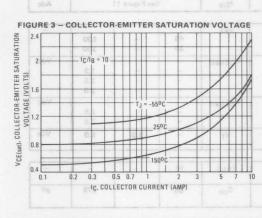
	Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTE	PIGURE 2 - COLLECTOR S (2) SZITZIR		MEAD	DC CURREN	- I saud	1
	Sustaining Voltage (Table 1)	VCEO(sus)	1 10	mait I		Vdc
	, I <sub>B</sub> = 0, V <sub>clamp</sub> = Rated V <sub>CEO</sub> ) MJ10002	CLO(sus)	350	S0+1-	1-1-1	
	MJ10003	THE PARTY	400		-	
Collector-Emitter	Sustaining Voltage (Table 1, Figure 12)	VCEX(sus)				Vdc
(IC = 1.0 A, V	clamp = Rated VCEX, TC = 100°C) MJ10002	SECT TO	400	100	17	
	MJ10003		450 275	7 1		
$(I_C = 5.0 \text{ A, V})$	clamp = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C) MJ10002 MJ10003		325		AI-	-
Callandar Codaff		logy	020			mAde
Collector Cutoff	ed Value, VBE(off) = 1.5 Vdc)	CEV			0.25	1
	ed Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)		had i		5.0	
Collector Cutoff		ICER	- <del>-</del> 7. 1	V	5.0	mAd
(VCE = Rated	V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)					
Emitter Cutoff C		IEBO		5 87 1	175	mAd
(VEB = 8.0 V	dc, I <sub>C</sub> = 0)		(0.004) 7 110		10 31	
SECOND BREAK						
Second Breakdov	vn Collector Current with base forward biased	lS/b		See Figure 11		Add
ON CHARACTE	RISTICS (2)					
DC Current Gain	DC Current Gain (IC = 2.5 Adc, VCE = 5.0 Vdc)		40	11111	500	
			40 30		500 300	
(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		N	30		300	Vdd
Collector-Emitter Saturation Voltage (IC = 5.0 Adc, IB = 250 mAdc)		VCE(sat)			1.9	Vac
In the last of the	IB = 1.0 Adc)	HINT		- 11111	2.9	
	, I <sub>B</sub> = 250 mAdc, T <sub>C</sub> = 100°C)	84 + 124			2.0	
Base-Emitter Sati		V <sub>BE(sat)</sub>		10.0.74		Vdd
	, I <sub>B</sub> = 250 mAdc)	DE (sat)	-	1-11	2.5	
(IC = 5.0 Add	, I <sub>B</sub> = 250 mAdc, T <sub>C</sub> = 100°C)		-	-	2.5	
Diode Forward \	/oltage (1)	Vf		3.0	5.0	Vd
(I <sub>F</sub> = 5.0 Add			PHI			
DYNAMIC CHA	RACTERISTICS					
Small-Signal Curr		Ihfel	10		+ -	-
	, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	The Real Property of	R R	1 13 6	6.0. \$1	1.0
	nce TWARROD ROTCHLEGO.GI	Cob	60	Enancy Transfer	275	pF
(V <sub>CB</sub> = 50 V <sub>C</sub>	dc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)					
	ARACTERISTICS					
Resistive Load (1	Table 1)	C WAY	120 2303	un correa	105 3 30	Hais
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A,	t <sub>d</sub>	WILLIAM TO	0.05	0.2	μs
Rise Time	$I_{B1} = 250 \text{ mA}, V_{BE(off)} = 5.0 \text{ Vdc}, t_p = 50 \mu s,$	tr		0.25	0.6	μs
Storage Time	Duty Cycle ≤ 2.0%).	t <sub>S</sub>	1-1	1.2	3.0	μs
Fall Time		tf		0.6	1.5	μѕ
Inductive Load,	Clamped (Table 1)				1-08001-5	
Storage Time	(I <sub>C</sub> = 5.0 A(pk), V <sub>clamp</sub> = Rated V <sub>CEX</sub> , I <sub>B1</sub> = 250 mA,	t <sub>sv</sub>		2.1	5.0	μѕ
Crossover Time	V <sub>BE(off)</sub> = 5.0 Vdc, T <sub>C</sub> = 100°C)	t <sub>c</sub>	10-1	1.3	3.3	μѕ
Storage Time	(IC = 5.0 A(pk), V <sub>clamp</sub> = Rated V <sub>CEX</sub> , I <sub>B1</sub> = 250 mA,	t <sub>sv</sub>		0.92		μѕ
Crossover Time	VBE(off) = 5.0 Vdc, TC = 25°C)	tc		0.5		μѕ

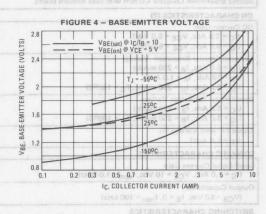
<sup>(1)</sup> The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast recovery rectifiers.

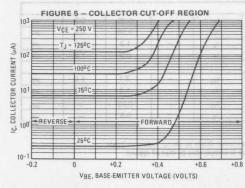
<sup>(2)</sup> Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%.











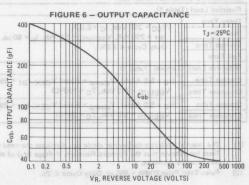
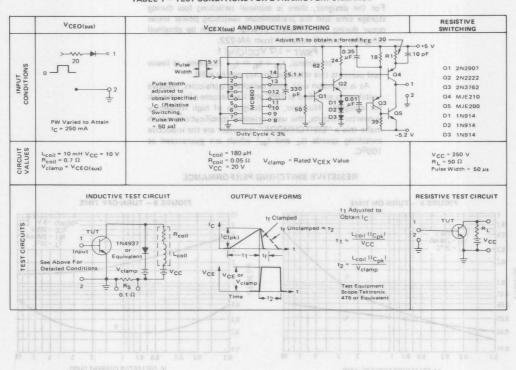
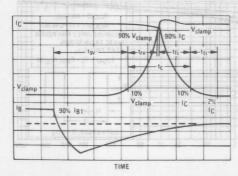


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



#### FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 7 to aid in the visual identity of these terms.

#### SWITCHING TIME NOTES (continued)

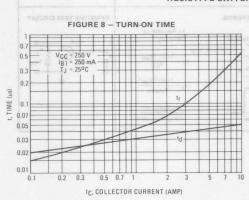
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

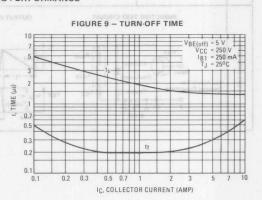
PSWT = 1/2 VCCIC(tc) f

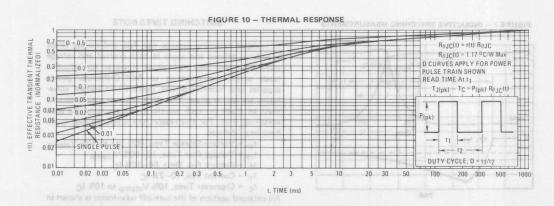
In general,  $t_{rv} + t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.

#### RESISTIVE SWITCHING PERFORMANCE









The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.

FIGURE 11 - ACTIVE-REGION SAFE OPERATING AREA

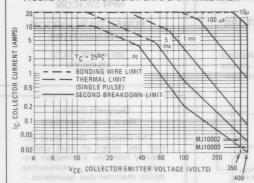
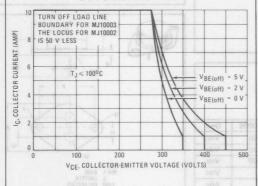


FIGURE 12 - REVERSE BIASED SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

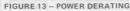
There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

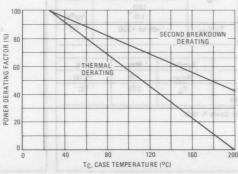
The data of Figure 11 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ} C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

TJ(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Tantanago

### REVERSE BIAS and and author of the second points in a

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as VCEX(sus) at a given collector current and represents a voltage-current condition that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete reverse bias safe operating area characteristics.





### Designers Data Sheet

#### SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS elds for 10 WITH BASE-EMITTER SPEEDUP DIODE

The MJ10004 and MJ10005 darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Deflection Circuits

Fast Turn-Off Times

40 ns Inductive Fall Time - 25°C (Typ) 650 ns Inductive Storage Time − 25°C (Typ) ≈100

Operating Temperature Range -65 to +200°C 100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads and agents and an arms.

Saturation Voltages

Leakage Currents and vicuospatiums beniataus ad



#### MAXIMUM RATINGS

MAXIMOMINATINGS		PERSONAL DEED TRIVE	91 1	1
Thans the Rating love a stages	Symbol	MJ10004	MJ10005	Unit
Collector-Emitter Voltage	VCEO(sus)	350 no	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	450	500	Vdc
Emitter Base Voltage	VEB and	8 12 dives	.0	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub> M	NATION AND ADDRESS.	0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		.5 .0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above 25°C	PD	10	75 ABW04 00 .0	Watts W/°C
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Symbol	Max	Unit
R <sub>θ</sub> JC	1.0	°C/W
TL	275	°C
	1	R <sub>θ</sub> JC 1.0

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

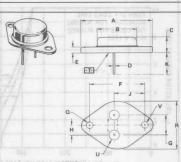
### 20 AMPERE NPN SILICON

#### POWER DARLINGTON TRANSISTORS

350 and 400 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.



STYLE 1 PIN 1. BASE 2. EMITTER CASE COLLECTOR

- ES:
  DIMENSIONS Q AND V ARE DATUMS.

  T-) IS SEATING PLANE AND DATUM.
  POSITIONAL TOLERANCE FOR
  MOUNTING HOLE Q:
- ♦ \$.13 (0.005) M T V M
- FOR LEADS:
- ♦ 0.13 (0.005) M T VM 0.M 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIA	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30,15 BSC		1.187 BSC		
G	10.92	BSC	0,430 BSC		
Н	5.48	BSC	0.21	BSC	
j	16.89 BSC		0.66	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1,050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

**CASE 1-05** TO-204AA

recovery rectifiers.

(2) Pulse Test: PW = 300 μs, Duty Cycle < 2%.

	CHARACTERISTICS (T <sub>C</sub> - 25°C unless otherwise note  Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTE		Symbol	IMIN	170	max	Jint
100103331	DELEGISTAD ROTOGLISON CARRAGE	v	WIND THE	100000	1 30000	Vdc
	Sustaining Voltage (Table 1)	VCEO(sus)	350			Vuc
(IC = 250 mA,	I <sub>B</sub> = 0, V <sub>clamp</sub> = Rated V <sub>CEO</sub> ) MJ10004 MJ10005		400	101-17		
			400			Vdc
	Sustaining Voltage (Table 1, Figure 12)	VCEX(sus)	400			Vuc 09
(IC - 2.0 A, V	Clamp = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C) MJ10004 MJ10005		450			
(Io = 10 A V	lamp = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C) MJ10004	-Karli I	275	The same		20
116 - 10 7, 46	MJ10005		325			01
Collector Cutoff C		ICEV		0-1		mAdc
(V <sub>CEV</sub> = Rated Value, V <sub>RE(off)</sub> = 1.5 Vdc)		CEV			0.25	DE
	d Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)		-	-	5.0	No.
Collector Cutoff C		ICER		1 30#	5.0	mAdc
	$V_{CEV}$ , $R_{BE} = 50 \Omega$ , $T_{C} = 100^{\circ}C$ )	CEIT				N or
Emitter Cutoff Cu		IEBO			175	mAdc
(VEB = 2.0 Vd		200				
SECOND BREAK		4 1	1		10-10	10 00
	n Collector Current with base forward biased	lon I	-	See Figure 11	10.00.01	
Second Breakdow	in Conector Current with base forward blased	IS/b		occi iguic i		
ON CHARACTER	RISTICS (2)		RETTIME O	protiins	- £ 39UD	18
	PIGURE 4 - SASE-EMITTER VOLTA	hFE	BDAT	OV MOITA	BATUE	
	V <sub>CE</sub> = 5.0 V(dc)		50		600	
(IC = 10 Adc, VCE = 5.0 Vdc)		1 1	40		400	
	Saturation Voltage	VCE(sat)				Vdc
	I <sub>B</sub> = 400 mAdc)	CEISALI	-	-	1.9	1
(I <sub>C</sub> = 20 Adc, I <sub>I</sub>				- 1	3.0	
	I <sub>B</sub> = 400 mAdc, T <sub>C</sub> = 100 <sup>o</sup> C)	NA III	1 -	-	2.0	
Base-Emitter Satu		VBE(sat)				Vdc
	I <sub>B</sub> = 400 mAdc)	DEISOLI		-	2.5	
(IC = 10 Adc,	I <sub>B</sub> = 400 mAdc, T <sub>C</sub> = 100 <sup>o</sup> C)	1 10	3-1	100 -1	2.5	2
Diode Forward V		Vf		3.0	5.0	Vdc
(IF = 10 Adc)			14 39			
DYNAMIC CHAR	ACTERISTICS		200	-	THE	1
Small-Signal Curre		Ihfel	10			1 -
	VCE = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	те і				
Output Capacitano		Cob	100	_	325	pF
	c, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	000	(9868) 74	депор нега	11103 31	P.
	ARACTERISTICS					
Resistive Load (Ta						
Delay Time	FIGURE 6 - OUTPUT CAPACITAN		DEN 9901	0.42	-000	TUBIH.
	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A,	<sup>t</sup> d	N	0.12	0.2	μs
Rise Time	$I_{B1} = 400 \text{ mA}, V_{BE(off)} = 5.0 \text{ Vdc}, t_p = 50 \mu s$	t <sub>r</sub>		0.2	0.6	μς
Storage Time	Duty Cycle ≤ 2%).	ts	-	0.6	1.5	μs
Fall Time		tf	151	0.15	0.5	μs
Inductive Load, C	lamped (Table 1)		1/1/19			
Storage Time	(IC = 10 A(pk), V <sub>clamp</sub> = Rated V <sub>CEX</sub> , I <sub>B1</sub> = 400 mA,	t <sub>sv</sub>	17 N	1.0	2.5	μѕ
Crossover Time	VBE(off) = 5.0 Vdc, T <sub>C</sub> = 100°C)	tc	-\-	0.4	1.5	μs
Storage Time	(IC = 10 A(pk), Vclamp = Rated VCEX, IB1 = 400 mA,	tsv	1 - 1	0.65		μs

(1) The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads.

Tests have shown that the Forward Recovery Voltage (V f) of this diode is comparable to that of typical fast

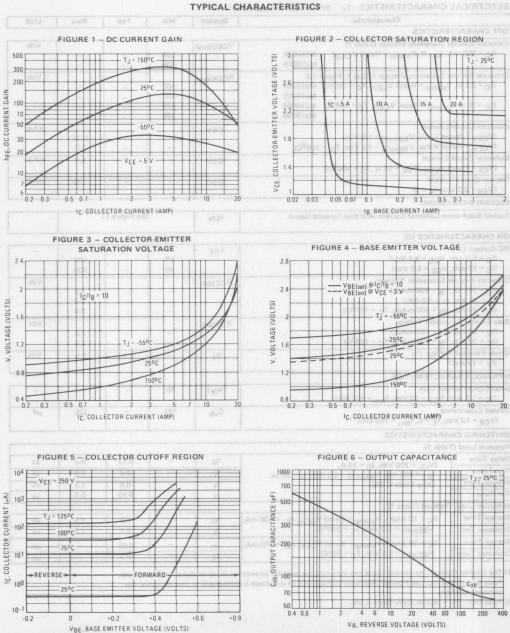
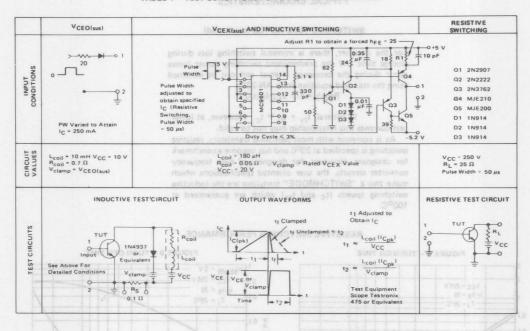
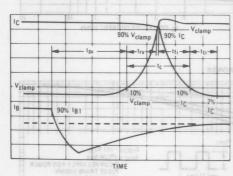


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



#### FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90–10% IC tti = Current Tail, 10–2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% IC

An enlarged portion of the turn-off waveforms is shown in Figure 7 to aid in the visual identity of these terms.

### TYPICAL CHARACTERISTICS

### SWITCHING TIME NOTES (continued)

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

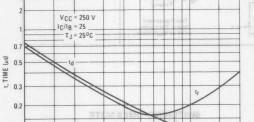
PSWT = 1/2 VCCIC(tc) f

In general,  $t_{rv} + t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\rm o}{\rm C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at  $100^{\rm o}{\rm C}$ .

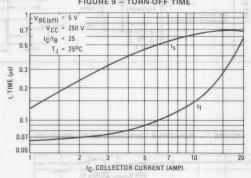
#### RESISTIVE SWITCHING PERFORMANCE



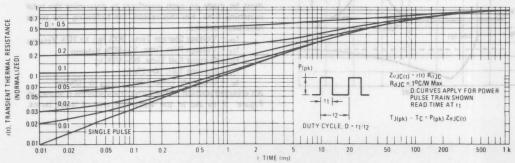


IC. COLLECTOR CURRENT (AMP)

#### FIGURE 9 - TURN-OFF TIME



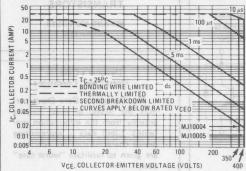
#### FIGURE 10 - THERMAL RESPONSE



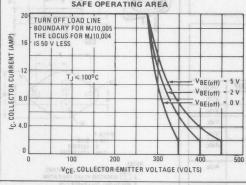
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The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.

#### FIGURE 11 - FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 12 – REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS AC SEMESTING MODELS MAIN

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

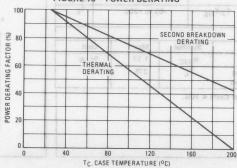
The data of Figure 11 is based on  $T_C=25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

 $T_{J(pk)}$  may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as VCEX(sus) at a given collector current and represents a voltage-current condition that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete reverse bias safe operating area characteristics.





350 AND 400 VOLTS 150 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design.

### Designers Data Sheet

#### SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10006 and MJ10007 darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
   Switching Regulators
- Inverters
- Solenoid and Relay Drivers
   O
- Motor Controls bridge 3985 S oT nedw be
- Deflection Circuits

Fast Turn-Off Times

30 ns Inductive Fall Time — 25°C (Typ) ≈100 500 ns Inductive Storage Time - 25°C (Typ)

Operating Temperature Range -65 to +200°C (Aq)

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

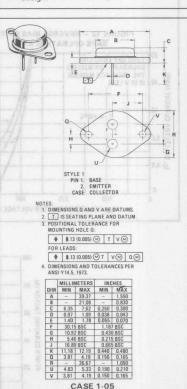
#### MAXIMUM RATINGS sullay pillipens a sucled to its level after

SVITOS AS (10 Rating 11 ISTSV82 YO	Symbol	MJ10006	MJ10007	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Emitter Voltage	VCEX(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	450	500	Vdc
Emitter Base Voltage	VEB	8.0	8.0	
Collector Current - Continuous - Peak (1)	IC ICM	10		Adc
Base Current - Continuous - Peak (1)	I <sub>BM</sub>	2.5		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	150 100 2017 A 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

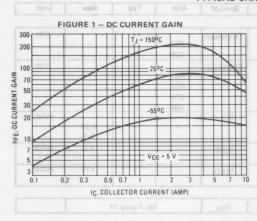


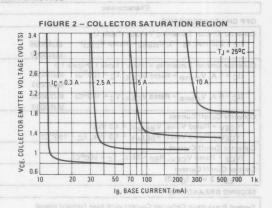
TO-204AA

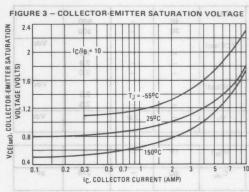
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS		MILLERY	CONSERUO D	g - 1 9949	13
Collector-Emitter Sustaining Voltage (Table 1)  (IC = 250 mA, IB = 0, V <sub>Clamp</sub> = Rated V <sub>CEO</sub> )  MJ10006  MJ10007	VCEO(sus)	350 400	081-130		Vdc 000
Collector-Emitter Sustaining Voltage (Table 1, Figure 12) (IC = 1 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C) MJ10006 MJ10007	VCEX(sus)	400			Vdc 081
(I <sub>C</sub> = 5 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C) MJ10006 MJ10007		275 325			100
Collector Cutoff Current $(V_{CEV} = Rated Value, V_{BE(off)} = 1.5 \text{ Vdc})$ $(V_{CEV} = Rated Value, V_{BE(off)} = 1.5 \text{ Vdc}, T_{C} = 150^{\circ}\text{C})$	ICEV			0.25 5.0	mAdc 15
Collector Cutoff Current $(V_{CE} = Rated V_{CEV}, R_{BE} = 50 \Omega, T_{C} = 100^{\circ}C)$	ICER	- V 2 -		5.0	mAdc
Emitter Cutoff Current (VEB = 2 Vdc, IC = 0)	IEBO		17 17 1	175	mAdc
SECOND BREAKDOWN BARRA SAR SAR SAR SAR SAR SAR SAR SAR SAR		(9MA) TM3	RETOR CLERK	1005.01	
Second Breakdown Collector Current with base forward biased	Is/b		See Figure 1	1	
ON CHARACTERISTICS (2)					
DC Current Gain (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	30 hFE V	40	e asttimi TĒTT	500 300	34 O C
Collector Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 250 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 250 mAdc, T <sub>C</sub> = 100°C)	VCE(sat)	-	<u> </u>	1.9 2.9 2.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 250 mAdc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 250 mAdc, T <sub>C</sub> = 100°C)	V <sub>BE</sub> (sat)	1	68 D	2.5 2.5	Vdc
Diode Forward Voltage (1) (I <sub>F</sub> = 5.0 Adc)	Vf	M	3.0	5	Vdc
DYNAMIC CHARACTERISTICS		-			5.0
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	Ihfel	10			4.0
Output Capacitance (VCB = 10 Vdc, IE = 0, f <sub>test</sub> = 100 kHz)	Cob	60	- 140 1988 US 8073	275	pF
SWITCHING CHARACTERISTICS					
Resistive Load (Table 1)					
Delay Time (V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A,	td	D38 1901	0.05	100 0.2	μs
Rise Time $I_{B1} = 250 \text{ mA}, V_{BE(off)} = 5.0 \text{ Vdc}, t_{D} = 50 \mu s_{1}$	tr	EX 1-4-5	0.25	0.6	μs
Storage Time Duty Cycle ≤ 2.0%).	ts	- Y- V	0.5	1.5	μs
Fall Time	tf	- 14	0.06	0.5	μѕ
Inductive Load, Clamped (Table 1)			-		and the second second
Storage Time (I <sub>C</sub> = 5.0 A(pk), V <sub>clamp</sub> = Rated V <sub>CEX</sub> , I <sub>B1</sub> = 250 mA,	·sv	1 - 1	0.8	2.0	μs
Crossover Time VBE(off) = 5.0 Vdc, T <sub>C</sub> = 100°C)	t <sub>c</sub>	4 - 4	0.6	1.5	μς
Storage Time (IC = 5.0 A(pk), V <sub>clamp</sub> = Rated V <sub>CEX</sub> , I <sub>B1</sub> = 250 mA,	t <sub>sv</sub>		0.5		μs
Crossover Time VBE(off) = 5.0 Vdc, TC = 25°C)	tc	-	0.3		μs

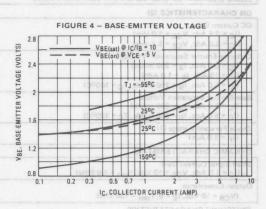
<sup>(1)</sup> The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast recovery rectifiers. fast recovery rectifiers.
(2) Pulse Test: PW = 300 μs, Duty Cycle < 2%.

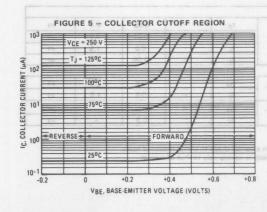
## TYPICAL CHARACTERISTICS TO SOLIT SOLITARIAND JACKETONIES











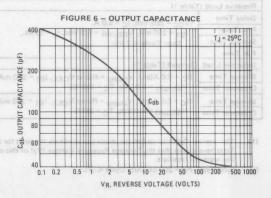


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

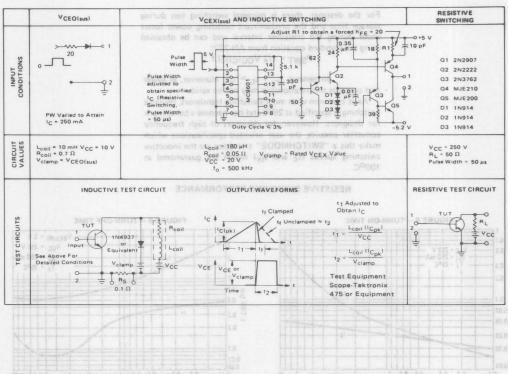
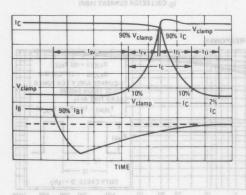


FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 7 to aid in the visual identity of these terms.

#### SWITCHING TIME NOTES (continued)

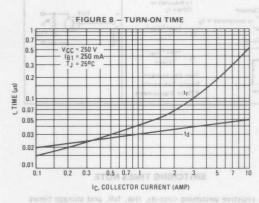
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

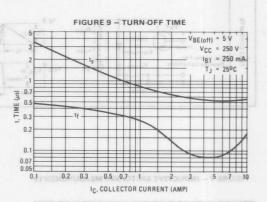
PSWT = 1/2 VCCIC(tc) f

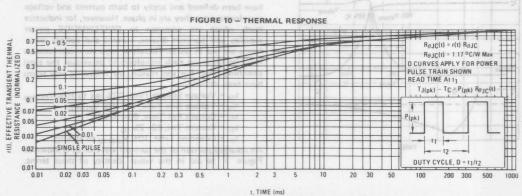
In general,  $t_{rv}$  +  $t_{fi}$   $\cong$   $t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\text{C}}$  and  $t_{\text{SV}}$ ) which are guaranteed at  $100^{\circ}\text{C}$ .

#### RESISTIVE SWITCHING PERFORMANCE







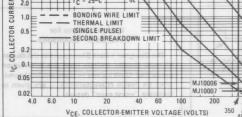
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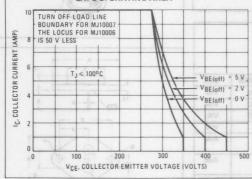
The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.

FIGURE 11 - FORWARD BIAS SAFE OPERATING AREA

## 5.0 T<sub>C</sub> = 25°C dc



#### FIGURE 12 - REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

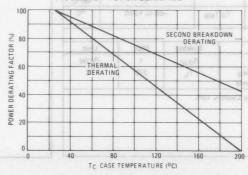
The data of Figure 11 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

TJ(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as V<sub>CEX(sus)</sub> at a given collector current and represents a voltage-current condition that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete reverse bias safe operating area characteristics.







### Designer's Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10008 and MJ10009 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

1.6  $\mu$ s (max) Inductive Crossover Time - 10 A, 100°C 3.5  $\mu$ s (max) Inductive Storage Time - 10 A, 100°C

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads
Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents



#### POWER DARLINGTON TRANSISTORS

450 and 500 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.



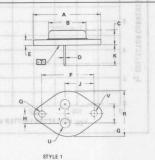
### MAXIMUM RATINGS sulay officees a worled to its level else

avisas as no Rating m Isravas yd	Symbol	MJ10008	MJ10009	Unit
Collector-Emitter Voltage	VCEO(sus)	450	500	Vdc
Collector-Emitter Voltage	V <sub>CEX</sub> (sus)	450	500	Vdc
Collector-Emitter Voltage	VCEV	650	700	Vdc
Emitter Base Voltage 3219491 printib	VEB	on that car	31	Vdc
Collector Current — Continuous — Peak (1)	ICM	30		Adc
Base Current — Continuous — Peak (1)	I <sub>BM</sub>	2.5		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	175 100		Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

### THERMAL CHARACTERISTICS MADORA SAS DATO 322

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1 /	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



STYLE 1
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

	MILLIN	METERS	INC	HES	
MIG	MIN	MAX	MIN	MAX	
A	-	39.37	-	1.550	
В	-	21.08		0.830	
C	6.35	7,62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30,15 BSC		1.187 BSC		
G	10.92	10.92 BSC		BSC	
Н	5.48	BSC	0.215 BSC		
J	16.89	BSC	- 0.830 0.250 0.300 0.038 0.043 0.055 0.070 1.187 BSC 0.430 BSC 0.215 BSC 0.665 BSC 0.440 0.480 0.150 0.165 - 1,050		
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26,67	-	1,050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

CASE 1-05 TO-204AA

≈100

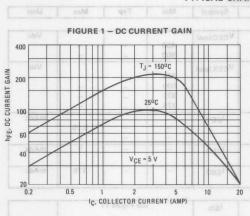
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Table 1)	VCEO(sus)	HAD TWO	17U0.00	Panhora	Vdc
(IC = 100 mA, IB = 0, V <sub>clamp</sub> = Rated V <sub>CEO</sub> ) MJ10008	CLO(303)	450		CONTRACTOR OF	0.04
MJ10009		500			
Collector-Emitter Sustaining Voltage (Table 1, Figure 12)	VCEX(sus)	39981	T I		Vdc
(I <sub>C</sub> = 2 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C, MJ10008		450	-	144-4-4	205
VBE(off) = 5 V) MJ10009		500	-		
(IC = 10 A, V <sub>clamp</sub> = Rated V <sub>CEX</sub> , T <sub>C</sub> = 100°C, MJ10008		325	-	114	
V <sub>BE(off)</sub> = 5 V) MJ10009	1-1-11/4	375	-		
Collector Cutoff Current	ICEV				mAdc
(VCEV = Rated Value, VBE(off) = 1.5 Vdc)	AL ALL			0.25	1 02
(V <sub>CEV</sub> = Rated Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	1-/	111	1	5	
Collector Cutoff Current	CER	-		1111111	mAdc
(V <sub>CE</sub> = Rated V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C) Emitter Cutoff Current	1//	1 1	1.334	175	mAdc
(V <sub>EB</sub> = 2 Vdc, I <sub>C</sub> = 0)	IEBO	117.1		1/5	MAGC
SECOND BREAKDOWN SP 1.0 80.0	19 20	1	2	0.5	0.2
Second Breakdown Collector Current with base forward biased	IS/b	(SWA) TRUB	See Figure 1	1	
	-3/0				
ON CHARACTERISTICS (2)					
DC Current Gain	hFE	40		400	-
(I <sub>C</sub> = 5 Adc, V <sub>CE</sub> = 5 Vdc)	B			300	
(IC = 10 Adc, VCE = 5 Vdc) 3 32A8 - 8 3RUDI3		30	ATION VO	300	11-1-
Collector-Emitter Saturation Voltage	VCE(sat)			2	Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 500 mAdc) (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2 Adc)		+		3.5	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 500 mAdc, T <sub>C</sub> = 100°C)	Maria			2.5	
Base-Emitter Saturation Voltage	V <sub>BE</sub> (sat)		1 10	3707	Vdc
(IC = 10 Adc, I <sub>B</sub> = 500 mAdc)	BE (sat)			2.5	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 500 mAdc, T <sub>C</sub> = 100°C)			1 -	2.5	1 121
Diode Forward Voltage (1)	Vf		3	5	Vdc
(I <sub>F</sub> = 10 Adc)	1 100		B - (T		1.2
DYNAMIC CHARACTERISTICS		IN			
Small-Signal Current Gain	Ihfel	8	1 -		
(IC = 1 Adc, VCE = 10 Vdc, f <sub>test</sub> = 1 MHz)	Te l	3002			8.0
Output Capacitance	Cob	100		325	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	- 00				1 1 1 1 1
SWITCHING CHARACTERISTICS		(SMA) Fu	ERRUD ROTOR	1100 at	00 3.0
Resistive Load (Table 1)		1.00001			
Delay Time	td	_	0.12	0.25	μs
Rise Time (V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A,	t <sub>r</sub> MU	USH <u>3</u> 401	0.5	1.5	μs
Storage Time IB1 = 500 mA, VBE(off) = 5 Vdc, $t_p = 25 \mu s$ Duty Cycle $\leq 2\%$ ).	ts	T - 1	0.5	2.0	из из
Fall Time	tf		0.8	0.6	μѕ
Inductive Load, Clamped (Table 1)	1 4 1	17	1 0.2	0.0	μ3
	1 + 1	777	1.5	3.5	иs
Storage Time $(I_C = 10 \text{ A(pk)}, V_{clamp} = 250 \text{ V}, I_{B1} = 500 \text{ mA})$ Crossover Time $V_{BE(off)} = 5 \text{ Vdc}, T_C = 100^{\circ}\text{C})$		1	0.36	1.6	
	t <sub>c</sub>	1/1	0.30	1.0	μѕ
Storage Time (IC = 10 A(pk), V <sub>clamp</sub> = 250 V, I <sub>B1</sub> = 500 m/	A, t <sub>sv</sub>	13	0.8	-09001	μs
Crossover Time VBE(off) = 5 Vdc)	t <sub>c</sub>	- 1	0.18		μѕ

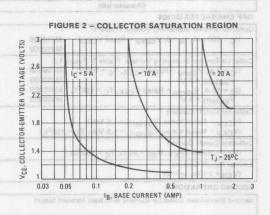
(1) The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads.

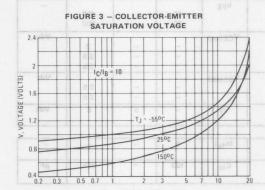
Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast

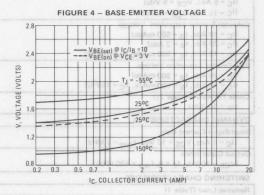
recovery rectifiers. (2) Pulse Test: PW = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

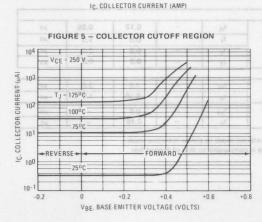












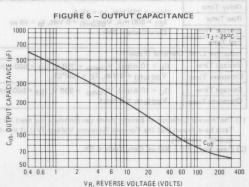
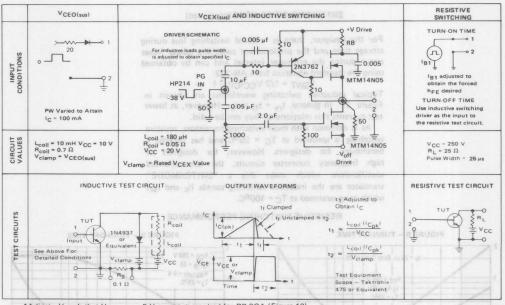
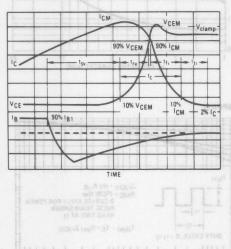


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



\*Adjust - V such that VBE(off) = 5 V except as required for RB SOA (Figure 12).

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS



#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

 $t_{SV}$  = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

t<sub>rv</sub> = Voltage Rise Time, 10–90% V<sub>clamp</sub> tfi = Current Fall Time, 90–10% I<sub>C</sub>

t<sub>ti</sub> = Current Tail, 10–2% I<sub>C</sub>

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

- continued -

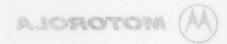
#### TYPICAL CHARACTERISTICS TOTAL TELEPROPERTY

#### SWITCHING TIMES NOTE (continued) For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222: PSWT = 1/2 VCCIC(tc) f Typical inductive switching waveforms are shown in Figure 7. In general, $t_{rv} + t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid. As is common with most switching transistors, resistive switching is specified at T<sub>C</sub> = 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at T<sub>C</sub> = 100°C. RESISTIVE SWITCHING PERFORMANCE FIGURE 9 - TURN-OFF TIME FIGURE 8 - TURN-ON TIME V<sub>CC</sub> = 250 V = 25 us. Duty Cycle 1<sub>C</sub>/I<sub>B</sub> = 20 VBE(off) = 5 V VCC = 250 V - IC/IB = 20 8.0 E 0.2 tp = 25 μs, Duty Cycle ≤ 2% 0.1 0.2 td 0.1 20 IC. COLLECTOR CURRENT (AMP) IC, COLLECTOR CURRENT (AMP) FIGURE 10 - THERMAL RESPONSE 0.7 TRANSIENT THERMAL RESISTANCE (NORMALIZED) D = 0.50.5 0.3 $$\begin{split} Z_{\ell l} J C_{(t)} &= r(t) \ R_{\ell l} J C \\ R_{\ell l} J C &= 1^{0} C_{\ell} W \ \text{Max} \\ D \ CURVES \ APPLY FOR POWER \\ PULSE \ TRAIN SHOWN \end{split}$$ 0.1 0.05 0.07 0.05 - 11 -READ TIME AT 11 0.03 12- $T_{J(pk)} - T_C = P_{(pk)} Z_{HJC(t)}$ 0.02 DUTY CYCLE, D = t1/t2 10 20 50 100 200 500 1 k

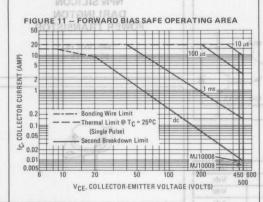
(3)

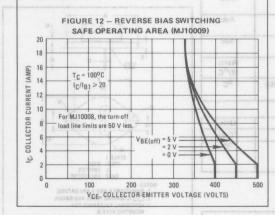
0.02

t TIME (ms)



The Safe Operating Area figures shown in Figures 11 and 12 are specified ratings for these devices under the test conditions shown.





# FIGURE 13 – POWER DERATING 100 100 80 Thermal Derating Derating To a so the standard Bias of the standard Bi

#### SAFE OPERATING AREA INFORMATION

HORIZONTAL DEFLECTION TRANSIST

#### **FORWARD BIAS**

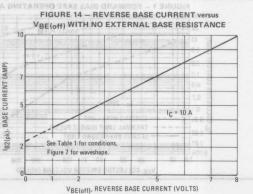
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

 $T_{J(pk)}$  may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as VCEX(sus) at a given collector current and represents a voltage-current condition that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete reverse bias safe operating area characteristics. See Table 1 for circuit conditions.





## MOITAMHORM ASPDARLINGTON AS HORIZONTAL DEFLECTION TRANSISTOR

specifically designed for use in deflection circuits.

- V<sub>CE(sat)</sub> = 3.0 Volts (Max) @ I<sub>C</sub> = 4.0 Amps, I<sub>B</sub> = 200 mA
  - Built-In Damper Diode
     Built-In Damper Diode
  - VCEX = 1400 Volts, and end needs notised and rests
- Glassivated Base-Collector Junction
  - Safe Operating Area @ 50 μs = 25 A, 200 V



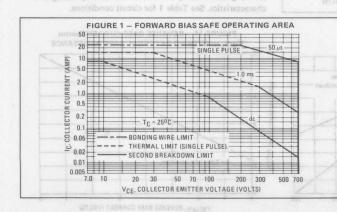
#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEX	1400	Vdc
Emitter Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous Peak (1)	I <sub>C</sub>	8.0 16	Adc
Base Current — Continuous Peak (1)	I <sub>B</sub>	2.0 4.0	Adc
Emitter Current — Continuous Peak (1) session rigid	I <sub>E</sub>	10 20	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	ed significance	0.6	Watts W/OC
Operating and Storage Junction Temperature Range		-65 to +150	°C

#### THERMAL CHARACTERISTICS bentally moons and med zint

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.56	°C/W
Maximum Lead Temperature for Soldering Purposes:	can be susta	275	ос
1.8" from Case for 5 Seconds	heitinev st na		1

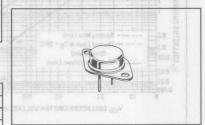
(1) Pulse Test: Pulse Width = 1.0 ms, Duty Cycle ≤ 10%.

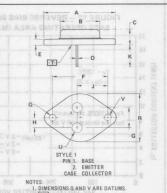


8.0 AMPERE O stad edT

NPN SILICON DARLINGTON POWER TRANSISTOR

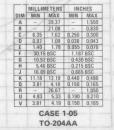
> 1400 VOLTS 80 WATTS

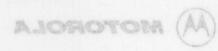




DIMENSIONS Q AND V ARE DATUMS.
 T IS SEATING PLANE AND DATUM.

- POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
- ♦ 0.13 (0.005) M T V M
- ♦ 0.13 (0.005) W T V W Q W DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.





2939MA Characteristic	HUIG	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)	transistor	ent darlington	ge, high-cum	high-volta	MJ10012 is a	eriT
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	-nea tese	V <sub>CEO(sus)</sub>	700	ioizir <u>ip</u> i avi	l for automol lications.	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 1400 Vdc, V <sub>BE</sub> = 0)		ICES	- Voitage -	Sustaining	0.25	mAdc
Emitter Cutoff Current (VBE = 4.0 Vdc, I <sub>C</sub> = 0)	Collector	IEBO	- (	iiM) ⇔V 0 V 08 ra vsi		mAdc
ON CHARACTERISTICS (1)					mortive Europ	e Auto
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.5 Adc, I <sub>B</sub> = 0.15 Adc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 0.2 Adc)		V <sub>CE(sat)</sub>	_	_	3.0 3.0	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 3.5 Adc, I <sub>B</sub> = 0.15 Adc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 0.2 Adc)	*	VBE(sat)	_	-	2.0 2.0	Vdc
Forward Diode Voltage (IF = 4.0 Adc)	200	≫ (Vf	-	1.2	2.0	Vdc
Second Breakdown Collector Current with Base Forw	ard Biased	I <sub>S/b</sub>		See F	igure 1	
SWITCHING CHARACTERISTICS	NIA 2011 II					
Fall Time (See Figure 2) (I <sub>C</sub> = 4.0 Adc, I <sub>B1</sub> = 0.2 Adc)		tf	-	0.65	1.0	μs

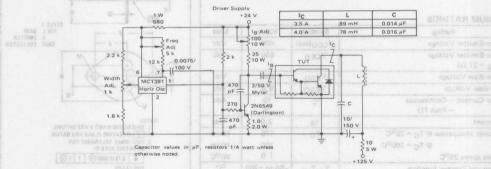
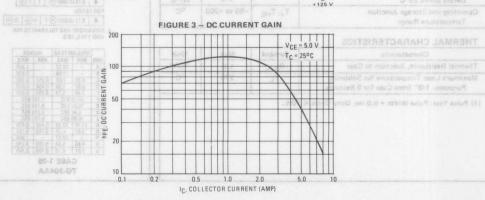


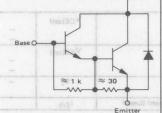
FIGURE 2 - FALL TIME TEST CIRCUIT





The MJ10012 is a high-voltage, high-current darlington transistor designed for automotive ignition, switching regulator and motor control applications.

- Collector-Emitter Sustaining Voltage -
- VCEO(sus) = 400 Vdc (Min)
- 175 Watts Capability at 50 Volts
- Automotive Functional Tests



Collector

#### 10 AMPERE

#### POWER TRANSISTOR DARLINGTON NPN SILICON

(VgE = 4.0 Vdc, ic = 0)

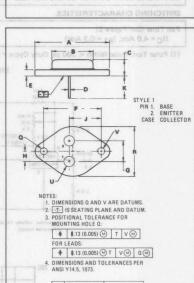
400 VOLTS (04) = 30V) 175 WATTS Hone Tenim

MAXIMUM RATINGS				V MC	
Rating	34870.0	Fine St	Symbol	Value	Unit
Collector-Emitter Voltage			V <sub>CEO</sub> (sus)	400	Vdc
Collector-Emitter Voltage (R <sub>BE</sub> = 27 $\Omega$ )		[	VCER	550	Vdc
Collector-Base Voltage		6.4	Vсво	600	Vdc
Emitter-Base Voltage			VEBO	8.0	Vdc
Collector Current — Continuo — Peak (1)	ous	27	1C	10 15	Adc
Base Current		101 J	IB	2.0	Adc
Total Power Dissipation @ T <sub>C</sub> @ T <sub>C</sub> Derate above 25 <sup>o</sup> C	= 100°C	The state of the s	PD	175 100 1.0	Watts Watts W/OC
Operating and Storage Junction Temperature Range			T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.0	°C/W
Maximum Lead Temperature for Soldering	/TL	275	оС
Purposes: 1/8" from Case for 5 Seconds	/		

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%...

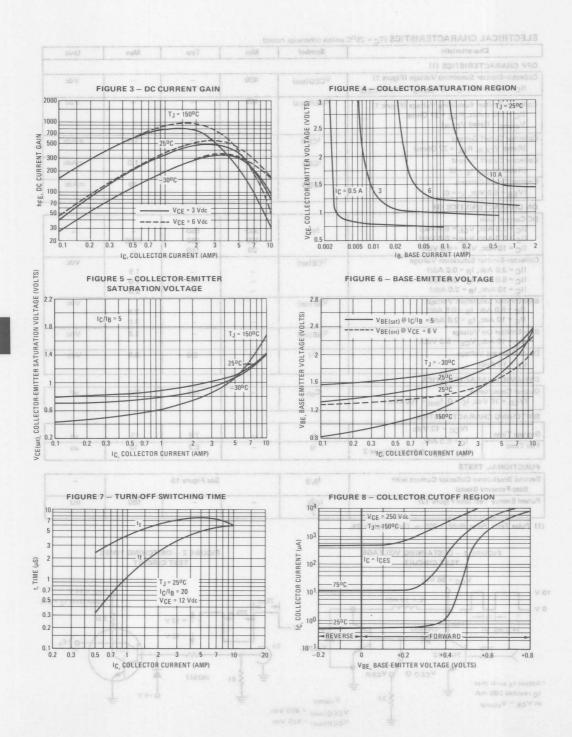


	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
Α	-	39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	1.40	1.78	0.055	0.070
F	30.15	BSC	1.187	7 BSC
G	10.92 BSC		0.430 BSC	
Н	5.48	BSC	0.215 BSC	
J	16.89	BSC	0.665 BSC	
K	11.18	12.19	0.440	0.480
0	3.81	4.19	0.150	0.165
R	-	26.67	-	1.050
U	4.83	5.33	0.190	0.210
٧	3.81	4.19	0.150	0.165

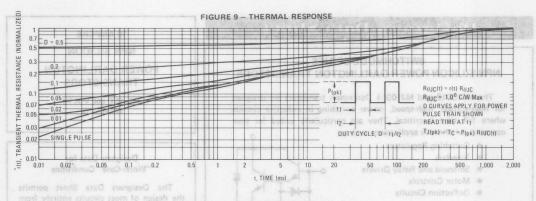
TO-204AA

Ch	aracteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACT	ERISTICS (1)					
	r Sustaining Voltage (Figure 1)	VCEO(sus)	400	CURRENT GAIN	GURE 3 – DC	Vdc
Collector-Emitte	er Sustaining Voltage (Figure 1)	VCER(sus)	425			Vdc
V <sub>clamp</sub> = Ra	Adc, R <sub>BE</sub> = 27 Ohms, ted V <sub>CER</sub> )	E 25		3º0ar = 1T		0
Collector Cutoff (Rated VCEF	Current R, RBE = 27 Ohms)	ICER	HILE	A = 39	1.0	mAdc
Collector Cutoff (Rated V <sub>CBC</sub>		СВО	W C		1.0	mAdc
Emitter Cutoff C (V <sub>EB</sub> = 6.0 V		IEBO	MAL	- 3-00	40	mAdc
ON CHARACTE	ERISTICS (1)	1 . 2	77	Ver = 3 Vde		1
DC Current Gain		7 8	741-1-	35V D = 30V	W. S. T. S.	
	c, V <sub>CE</sub> = 6.0 Vdc)	hFE	300	550		-
	, V <sub>CE</sub> = 6.0 Vdc)	200.0	100	350 150	2000	0.2
	r Saturation Voltage	V <sub>CE(sat)</sub>	20	PRINCIPALITY OF THE PRINCI	10. COLLECT	Vdc
(IC = 3.0 Add	c, I <sub>B</sub> = 0.6 Adc)	OL (Sat)	-	-	1.5	
	o, I <sub>B</sub> = 0.6 Adc) 3 3 3 4 8 - 9 3 FUDI , I <sub>B</sub> = 2.0 Adc)		_	CTOR-EMITTER VOLTAGE	2.0	0613
Base-Emitter Sat		VBE (sat)	HILL		0.5	Vdc
	c, I <sub>B</sub> = 0.6 Adc)		HITT		2.5 3.0	gi 1
Base-Emitter On		VBE(on)	0=181 = (1		2.8	Vdc
Diode Forward \		Vf	NA I	2.0	3.5	Vdc
(I <sub>F</sub> = 10 Adc	) 3º0E17		308			
DYNAMIC CHA	RACTERISTICS	8.1 🗒	HILL S			
Output Capacita (V <sub>CB</sub> = 10 V	nce dc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	C <sub>ob</sub>		165	350	pF
SWITCHING CH	ARACTERISTICS					
Storage Time	(V <sub>CC</sub> = 12 Vdc,	ts	HUIT	7.5	15	иѕ
Fall Time	I <sub>C</sub> = 6.0 Adc,	tf	61 1 6	5.2	15	μs
	I <sub>B1</sub> = I <sub>B2</sub> = 0.3 Adc) Figure 2			(RMA) TRIBERT	IC, COLLECTOR	
Second Breakdon	TESTS wn Collector Current with	IS/B		See Figure 10		_
Base-Forward	CONTRACTOR OF THE PARTY OF THE	1719		THE DULL THE	- TURNOT	5 380003
Pulsed Energy Te	est (See Figure 12)	I <sub>C</sub> 2 <sub>L</sub>			180	mJ
	ulse Width = 300 µs, Duty Cycle = 2%.  RE 1 - SUSTAINING VOLTAGE TEST CIRCUIT  V <sub>CC</sub> = 20 Vdc	101 E		FIGURE 2 – SWI TEST C		S
, I	L = 10 mH		25 μs	16/18 = 30 VCE = 12 Vde		V <sub>CC</sub> ≈ 14 V Adjust Until I <sub>C</sub> =
-   t <sub>1</sub>	100 1N4933	0-	225 μ	T ≈ 12 V	*	2 52
220 W	2N3713	Vclamp	En	SMAI THERRUS	TUT	) E <sub>0</sub>
Adjust t <sub>1</sub> such th	1A = \$27	V	± ₹5	1 IN3947	J-4v ]	
1/ - 1/	\$ 27	V <sub>clamp</sub>	=		=	
at VCE = Vclamp	1	/CEO(sus) = 400 \	/dc			

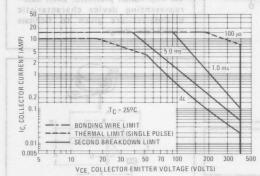








#### Timil bettered not smooth FIGURE 10 - FORWARD BIAS SAFE OPERATING AREA

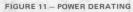


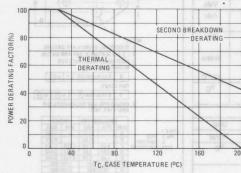
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

e Fast Turn-Off Times

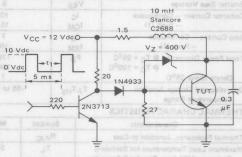
The data of Figure 10 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 11.

T<sub>J</sub>(p<sub>k</sub>) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





#### FIGURE 12 - USAGE TEST CIRCUIT



 $\mathbf{t}_1$  to be selected such that  $\mathbf{I}_C$  reaches 6 Adc before switch-off. NOTE:

"Usage Test," Figure 12 specifies energy handling capabilities in an automotive ignition circuit.



# Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS

The MJ10013 and MJ10014 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits



• Fast Turn-Off Times

250 ns Inductive FAII Time—25°C (Typ) 500 ns Inductive Crossover Time—25°C (Typ) 1.4 µs Inductive Storage Time—25°C (Typ)

- Operating Temperature Range: -65 to +200°C
- 100°C Performance Specified for:
   Reversed Biased SOA With Inductive Loads
   Switching Times With Inductive Loads
   Saturation Voltages

Leakage Currents and as amag

#### the power that can be handled to SDNITAR MUMIXAM

Rating	Symbol	MJ10013	MJ10014	Unit
Collector-Emitter Voltage	VCEO(sus)	550	600	Vdc
Collector-Emitter Voltage	VCEV	650	700	Vdc
Emitter Base Voltage	VEB		8	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub> M	10 15		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub> M	7 10		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	Charles I .	75 00	Watts W/°C
	4			
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

THE TIME OF A TENOTION						
Characteristic	Symbol	Max	Unit			
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1	°C/W			
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T <sub>L</sub>	275	ons °C			

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%

#### 10 AMPERE

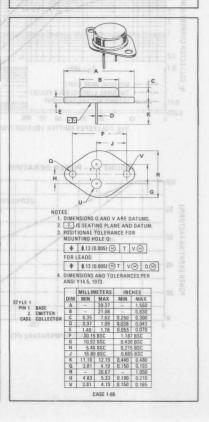
NPN SILICON

#### POWER DARLINGTON TRANSISTORS

550 AND 600 VOLTS 175 WATTS

#### Designers Data for "Worst-Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data—representing device characteristic boundaries—are given to facilitate "worst-case" design.



3

## TYPICAL CHARACTERISTICS

MOI	FIGURE 2 COLLECTOR SATURATION REG		1111	RRENT GA	15.7 – DC CU	FIGUI
			THE	11		
ELECTRICAL	CHARACTERISTICS (T <sub>C</sub> = 25°C unless otherwise no	ted)				
	Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACT	ERISTICS					Police
Collector-Emitte	r Sustaining Voltage (Table 1) A, IB = 0) MJ10013 MJ10014	VCEO(sus)	550 600	1		Vdc
	Current  red Value, VBE(off) = 1.5 Vdc) red Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEV		A S = 40 A	0.3	mAdc
Collector Cutoff (VCE = Rated	Current d V <sub>CEV</sub> , R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	ICER			5	mAdc
Emitter Cutoff C		IEBO	S = 8 MPI	t - t L rushbus /	1.01750 01032400 gl	mAdc
SECOND BREA	KDOWN					
Second Breakdown Collector Current with base forward biased		1S/b	See Figure 12		FIGUR	
Clamped Inducti	ive SOA with Base Reverse Biased	RBSOA		See Figure	130TARUT	2
ON CHARACTE	RISTICS (2)	9777			mili	
	V <sub>CE</sub> = 5 Vdc)	hFE	20		500	
(IC = 10 Add	r Saturation Voltage , I <sub>B</sub> = 2 Adc) , I <sub>B</sub> = 2 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)	VCE(sat)	3-8/5/	- 01 - ghgl	2.5 2.6	Vdc
Base-Emitter Sat (IC = 10 Adc, (IC = 10 Adc,		V <sub>BE</sub> (sat)		1	3	Vdc
Diode Forward 1 (IF = 10 Add		Vf		3	5	Vdc
DYNAMIC CHA	RACTERISTICS					
Small-Signal Cur (I <sub>C</sub> = 1 Adc,	rent Gain VCE = 10 Vdc, f <sub>test</sub> = 1 MHz) 05 gl	Ih <sub>fe</sub> !	10	CURRENT (A)	10. E017EELOV	£0 <u>£0</u>
Output Capacita (V <sub>CB</sub> = 10 V	nce dc, I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	C <sub>ob</sub>	100	-	350	pF
SWITCHING CH	HARACTERISTICS		MOIDES	atanzun	0102100	7 20110
Resistive Load (						
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A,	td		0.02	0.2	μѕ
Rise Time	I <sub>B1</sub> = 400 mA, V <sub>BE</sub> (off) = 5 Vdc, t <sub>p</sub> = 50 μs,	tr		0.9	2	- ν υριμε <sub>33</sub>
Storage Time Fall Time	Duty Cycle ≤ 2%).	t <sub>s</sub>		0.95	4	μs
	- 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1			The state of the s	

(I<sub>C</sub> = 10 A(pk), V<sub>clamp</sub> = 250 Vdc, I<sub>B1</sub> = 1 A, V<sub>BE(off)</sub> = 5 Vdc, T<sub>C</sub> = 100°C)

(I<sub>C</sub> = 10 A(pk), V<sub>clamp</sub> = 250 Vdc, I<sub>B1</sub> = 1 A, V<sub>BE(off)</sub> = 5 Vdc, T<sub>C</sub> = 25<sup>o</sup>C)

Inductive Load, Clamped (Table 1)

Storage Time

Crossover Time

Storage Time

Crossover Time

3

ts

tc

ts

tc

tfi

2.3

1.4

0.5

6

μѕ

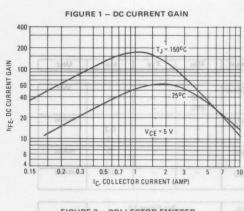
μs

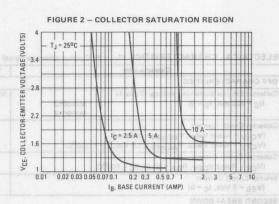
μs

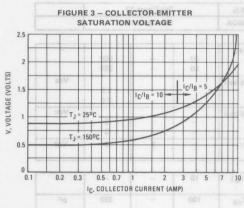
<sup>(1)</sup> The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast recovery rectifiers.

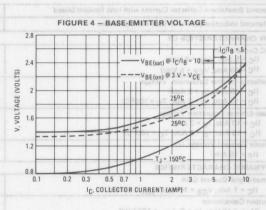
<sup>(2)</sup> Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%.

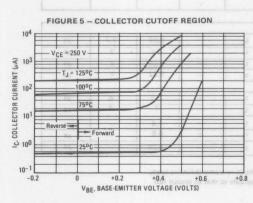
#### TYPICAL CHARACTERISTICS











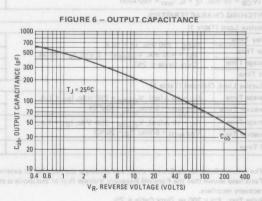
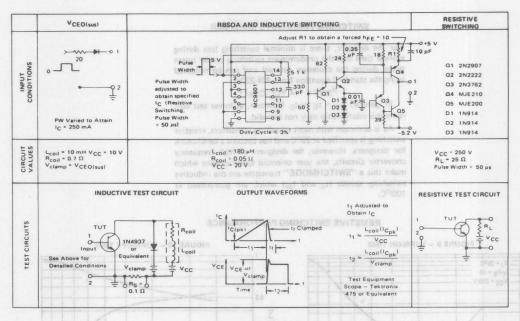


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



#### SWITCHING TIME NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

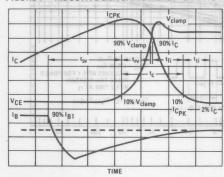
tti = Current Tail, 10-2% IC

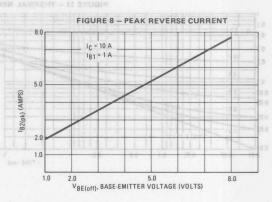
t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 7 to aid in the visual identity of these terms.

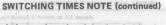
- continued -

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS





#### TYPICAL CHARACTERISTICS



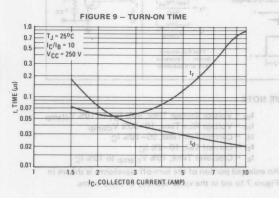
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

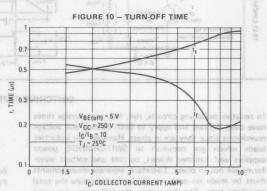
#### PSWT = 1/2 VCCIC(tc) f

In general,  $t_{\Gamma V}$  +  $t_{fi}$   $\simeq$   $t_{C}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\text{C}}$  and  $t_{\text{SV}}$ ) which are guaranteed at  $100^{\circ}\text{C}$ .

#### RESISTIVE SWITCHING PERFORMANCE









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The Safe Operating Area figures shown in Figures 12 and 13 are specified for theses devices under the test conditions shown.

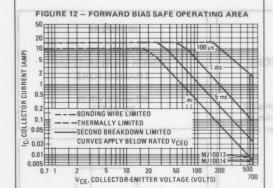
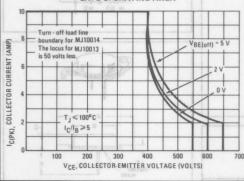


FIGURE 13 - REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCF limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

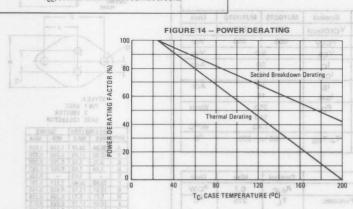
The data of Figure 12 is based on Tc = 25°C; T I(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>I</sub>(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.

# Fast Turn-Off Times



3-831

specified for theres devices under the cest conditions speem

SAFE OPERATING AREA INFORMATION

RWARD BIAS

There are two limitations on the power handling abil

SWITCHMODE SERIES

NPN SILICON POWER DARLINGTON TRANSISTORS

WITH BASE-EMITTER SPEEDUP DIODE

The MJ10015 and MJ10016 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators (Morth beliafunded and years (Agr), T.
- Motor Controls I mil lamed assurancement assortion 12.
- Inverters and souler of bellomen ad new tent noway arts
- Solenoid and Relay Drivers
- Fast Turn-Off Times
   1.0 us (max) Inductive Crossover
  - 1.0  $\mu$ s (max) Inductive Crossover Time 20 Amps 2.5  $\mu$ s (max) Inductive Storage Time 20 Amps
- Operating Temperature Range 65 to +200°C
- Performance Specified for

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents

MAXIMUM RATINGS

Rating	Symbol	MJ10015	MJ10016	Unit
Collector-Emitter Voltage	VCEO(sus)	400	500	Vdc
Collector-Emitter Voltage	VCEV	600	700	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	50 35 75		Adc
Base Current — Continous — Peak (1)	I <sub>B</sub>	10 15		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	250 143 1.43		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	°C	

#### THERMAL CHARACTERISTICS

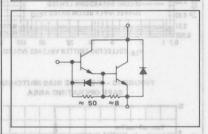
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.7	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

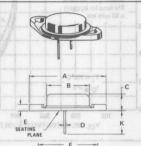
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%

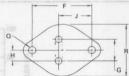
#### 50 AMPERE

# NPN SILICON POWER DARLINGTON TRANSISTORS

400 and 500 VOLTS 250 WATTS







STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
. A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	24.89	26.67	0.080	1.050

CASE 197-01 MODIFIED TO-3

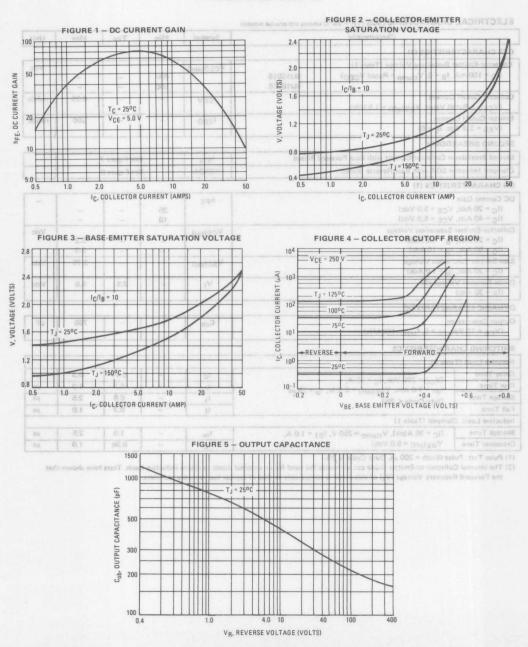
3

Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS (1)			THE	-		HI
	ustaining Voltage (Table 1) B = 0, V <sub>clamp</sub> = Rated V <sub>CEO</sub> )	MJ10015 MJ10016	VCEO(sus)	400 500	-		Vdc
Collector Cutoff Cu (V <sub>CEV</sub> = Rated	rrent Value, V <sub>BE(off)</sub> = 1.5 Vdc)	TITAL S	ICEV		Tc - 26%C	0.25	mAdo
Emitter Cutoff Curi (VEB = 2.0 Vdc		V0 12	IEBO		10.5.70A	350	mAdo
SECOND BREAKD	OWN		Z				Ш,
Second Breakdown	Collector Current with Base Forwar	d Biased	I <sub>S/b</sub>	-1111	See Figure 7		H
Clamped Inductive	SOA with Base Reverse Biased		RBSOA		See Figure 8		HH.
ON CHARACTERIS	STICS (1)	2.0	20 %	01	Ad I	1.0 2.1	8.0
DC Current Gain  (I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 5.0 Vdc)  (I <sub>C</sub> = 40 Adc, V <sub>CE</sub> = 5.0 Vdc)		hFE	25 10	_ _ #801233710	-	-	
Collector-Emitter Sa (I <sub>C</sub> = 20 Adc, I <sub>B</sub> (I <sub>C</sub> = 50 Adc, I <sub>B</sub>	= 1.0 Adc) 01 38 1100 - 4 38 US	17	VCE(sat)	SATURA	nart <u>i</u> wa 1	2.2	Vdc
Base-Emitter Satura	tion Voltage	DV T	V <sub>BE(sat)</sub>			2.75	Vdc
Diode Forward Volt (I <sub>F</sub> = 20 Adc)	tage (2)	y i	Vf		2.5	5.0	Vdc
DYNAMIC CHARA	CTERISTIC	Str. 10	HAV	- 1111	111		
Output Capacitance (V <sub>CB</sub> = 10 Vdc,	I <sub>E</sub> = 0, f <sub>test</sub> = 100 kHz)	161 26	Cob			750	pF
SWITCHING CHAP	ACTERISTICS	1000		-184		-	1
Resistive Load (Tab	le 1)	P01 **			-		HH
Delay Time	(Vcc = 250 Vdc, Ic = 20 A,	and the same of th	t <sub>d</sub>		0.14	0.3	μs
Rise Time	IB1 = 1.0 Adc, VBE(off) = 5 Vdc,	t <sub>n</sub> = 25 μs	t <sub>r</sub>	11111	0.3	1.0	μs
Storage Time	Duty Cycle ≤ 2%).		t <sub>S</sub>	THE THE PARTY	0.8	2.5	μs
Fall Time			tf	100	0.3	1.0	μs
Inductive Load, Cla							
Storage Time	$(I_C = 20 \text{ A(pk)}, V_{clamp} = 250 \text{ V}, I_{clamp} = 250 \text{ V}, I_{clamp} = 250 \text{ V}$		t <sub>sv</sub>		1.0	2.5	μs
Crossover Time	VBE(off) = 5.0 Vdc)	LIPUT CAPACITAN	tc	-	0.36	1.0	μs

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.

(2) The internal Collector-to-Emitter diode car. eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast recovery rectifiers.

#### TYPICAL CHARACTERISTICS

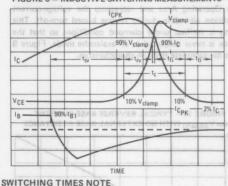


RESISTIVE VCEO(sus) VCEX AND INDUCTIVE SWITCHING SWITCHING TURN ON TIME Adjust R1 to obtain a forced her = 20 (1) CONDITIONS 62 I<sub>B1</sub> adjusted to obtain the forced Pulse Width -02 -012 obtain specified I<sub>C</sub> (Resistive heE desired TURN-OFF TIME PW Varied to Attain Pulse Width = 25 µs) Use inductive switching circuit as the input to the resistive test circuit. IC = 100 mA Duty Cycle ≤ 3% L<sub>coil</sub> = 10 mH V<sub>CC</sub> = 10 V R<sub>coil</sub> = 0.7 Ω L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V Q1 2N2907 05 MJE200  $V_{CC}$  = 250 V R<sub>L</sub> = 12.5  $\Omega$ Pulse Width = 1N914 1N914 Q2 2N2222 D1 Q3 2N3762 D2 Vclamp " VCEO(sus) Q4 MJE210 D3 1N914 INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT ta Adjusted to Obtain Ic CIRCUITS RL TUT FRL VCC 1N4937 Lcoil (ICpk) TEST t<sub>2</sub> ≈ V<sub>clamp</sub> Detailed Condit Test Equipment Scope - Tektronix 475 or Equivalent Time 12-

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

#### FIGURE 6 - INDUCTIVE SWITCHING MEASUREMENTS

\*Adjust - V such that VBE(off) = 5 V except as required for RB SOA (Figure 8).



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power-supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% IB1 to 10% V<sub>clamp</sub>

 $t_{rv}$  = Voltage Rise Time, 10 – 90%  $V_{clamp}$   $t_{fi}$  = Current Fall Time, 90 – 10%  $I_{C}$ 

t<sub>ti</sub> = Current Tail, 10 - 2% I<sub>C</sub>

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

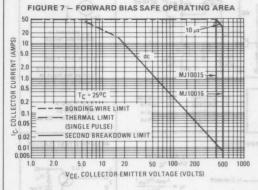
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

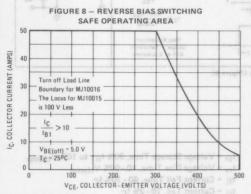
## $P_{SWT} = 1/2 V_{CCIC}(t_c) f$

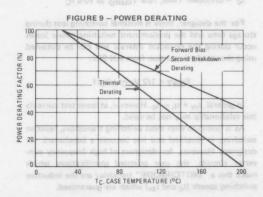
In general,  $t_{rV}$  +  $t_{fi} \cong t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>G</sub> and t<sub>SV</sub>) which are quaranteed.

The Safe Operating Area figures shown in Figures 7 and 8 are specified ratings for these devices under the test conditions shown.







#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

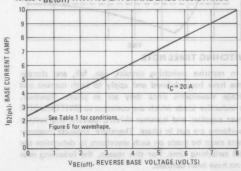
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on  $T_C=25^{o}C;T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 7 may be found at any case temperature by using the appropriate curve on Figure 9.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 8 gives the complete RBSOA characteristics.







## Designers Data Sheet

#### SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10020 and MJ10021 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for lineoperated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers

Leakage Currents

- Fast Turn-Off Times 150 ns Inductive Fall Time at 25°C (Typ) 750 ns Inductive Storage Time at 25°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for: Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages



MAXIMUM RATINGS				
Rating	Symbol	MJ10020	MJ10021	Unit
Collector-Emitter Voltage	VCEO(sus)	200	250	Vdc
Collector-Emitter Voltage	VCEV	300	350	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>		00 2 A 00	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		0 0 A 0 1	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	0 2	50	Watts
@ T <sub>C</sub> = 100°C		145 14	43	
Derate above 25°C		1.	43	W/oc
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	oC.

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	0.7	oc/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	oC

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%

#### 60 AMPERE

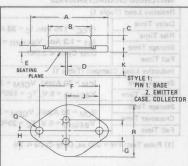
#### NPN SILICON POWER DARLINGTON **TRANSISTORS**

200 and 250 VOLTS 250 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.



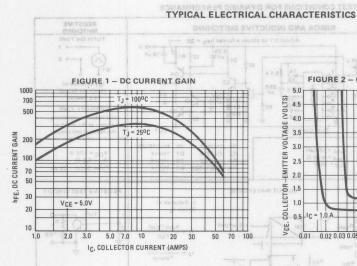


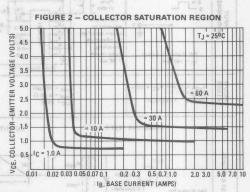
	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

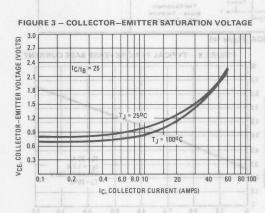
CASE 197-01 MODIFIED TO-3 MJ10021

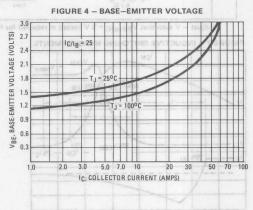
	Characteristic			Symbol	Min	Тур	Max	Unit	92
OFF CHARACTE						- 7,-		-	-
	Sustaining Voltage (Table 1)		MJ10020	VCEO(sus)	200	NITCHING	3	Vdc	7
(I <sub>C</sub> = 100 mA,			MJ10021	VCEO(sus)	250	AC BRIDE	DS MEDDIL	NPN SI	
Collector Cutoff C			11010021	CEV	ER SPEEC	E-EMITT	PAS HTIM	mAdc	-
	d Value, VBE (off) = 1.5 Vdc)			CEVIO	2723-10-127	X / 118821-21	0.25	made	
	Value, VBE(off) = 1.5 Vdc, TC =	150°C)			_	_	5.0		
Collector Cutoff C			e designed	CER	r nearmities	1500160	5.0	mAdc	1
(VCE = Rated	VCEV, RBE = 50 Ω, TC = 100°C)			naubni ni g	niriotiwa nev	speed, pay	ottage, high	or high-v	1
mitter Cutoff Cu	rrent		ami 101 l	IEBO	are_partic	itical_The	175	mAdc	1
$(V_{EB} = 2.0 V,$	I <sub>C</sub> = 0)				such as:	applications	witchmeda	perated s	)
ECOND BREAK	DOWN		1			slostnoi	Controls 200	hos OA 4	
econd Breakdowi	Collector Current with base forw	ard biase	d	Is/b		See Fig	ure 13		
lamped Inductive	SOA with Base Reverse Biased			RBSOA		See Fig	ure 14	1031966	1
N CHARACTER	ISTICS (1)	1	7	1			51	allevel a	
C Current Gain	s saom to ngitab aris	7	2	hee	75	Drivers	1000	Saleno	
	VCE = 5.0 V)						miT itO-on	Past Tu	
	Saturation Voltage		1 27 = 1	VCE(sat)	R 25°C (TV	Fall Time	ins Inductive	0 Vdc	
	B = 1.2 Adc)			(gyT	ne at Z5°C		2.2		
	B = 4.0 Adc)			1967	-	-	4.0		
	B = 1.2 Adc, T <sub>C</sub> = 100°C)			U.	-65 to +200	ture Bings	2.4	Operat	
lase-Emitter Satur				VBE(sat)	170	Specified t	Performano	Vdc	1
(Ic = 30 Adc, I	B = 1.2 Adc) B = 1.2 Adc, T <sub>C</sub> = 100°C)			spe	uductive Fo	SOAWIN	3.0		
oiode Forward Vo				Vf	shed Loads	autho I drive		Md-	+
(IF = 30 Adc)	tage			Vf		2.5	Jov 5.0	Vdc	
YNAMIC CHAR	ACTERISTICS					2	cage Gurrent	EOU	_
Output Capacitano				Cob	175		700	pF	7
	, IE = 0, f <sub>test</sub> = 1.0 kHz)			оор	175		700	pr	
									_
WITCHING CHA									-
Resistive Load (Ta	ble 1)						00007	en course	KA
Delay Time	(VCC = 175 Vdc, IC = 30 A,	tint		<sup>t</sup> d	- Tanana 3	0.02	0.2	μs	
Rise Time	IB1 = 1.2 Adc, VBE(off) = 5.0			tr		0.30	1.0	μs	sile
torage Time	Duty Cycle ≤ 2.0%).	Vdc	350	t <sub>S</sub>	7014017/221-1	1.0	3.5	μς	afte
all Time				tf	- A3-7	0.07	0.5	μs	2100
nductive Load, CI	amped (Table 1)	- nh A		02			0,000		-
Storage Time	I <sub>CM</sub> = 30 A(pk), V <sub>CEM</sub> = 200	V, IB1 =	1.2 A,	t <sub>sv</sub>	1201	1.2	3.5	μs	otle
Prossover Time	VBE(off) = 5 V, TC = 100°C)			t <sub>c</sub>	7	0.45	2.0	μs	020
torage Time	(1-1-20 A(ak) V	V 1	120	os t <sub>sv</sub>	1/Tai	0.75	Til sted	μς	1
Crossover Time	(I <sub>CM</sub> = 30 A(pk), V <sub>CEM</sub> = 200 V <sub>BE(off)</sub> = 5 V, T <sub>C</sub> = 25°C)	v, 'B1 =	1.2 A,	t <sub>c</sub>	73	0.25	nT @ holted	μѕ	Isro
all Time	ARE(011) - 2 A' 1C - 520C)			tfi	-	0.15	2T 9-	μs	1
1) Pulse Test: PW	= 300 µs. Duty Cycle ≤ 2%	DOIM		CALT			2500	avods ster	Dis
	200,241,3100,220	30					nolranut ageno	ung and St	
							Range	mutaneon	υT
2311311						STICS		HO JAME	
	A 20.16 39,37			Lodenv8	1				
	80.12 80.21 3				-				-
							ce, Junction b		
							emperature for a Secon		
							disa Width = 5		
	Tartifac I								
103.0 F22.0									

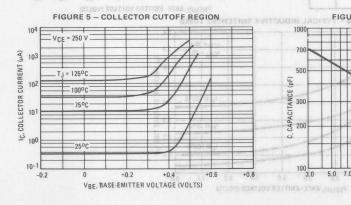












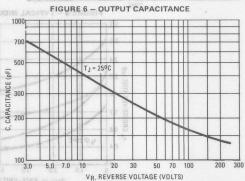
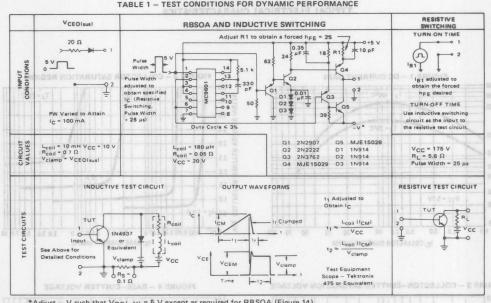
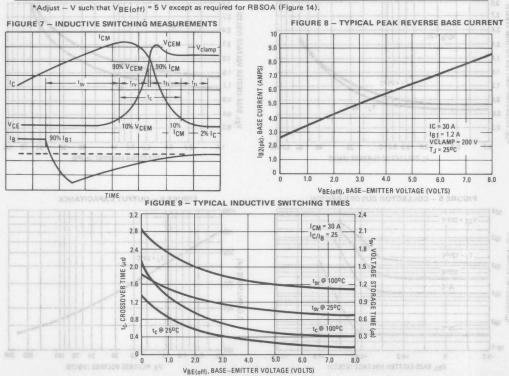


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE





## MOLTAMROUND AREA DURTHARDED SWITCHING TIMES NOTE: 27 eaught in Property of the Area Representation of

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

 $t_{SV}$  = Voltage Storage Time, 90% IB1to 10% VCEM

trv = Voltage Rise Time, 10 - 90% VCEM

 $t_{fi}$  = Current Fall Time, 90 - 10% I<sub>CM</sub>

tti = Current Tail, 10 - 2% ICM

 $t_{\text{C}}$  = Crossover Time, 10%  $V_{\text{CEM}}$  to 10%  $I_{\text{CM}}$  An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:  $P_{SWT} = 1/2 \ V_{CCIC}(t_c) f$ 

specified for their devices under the test conditions

In general,  $t_{\text{TV}}$  +  $t_{\text{fi}} \cong t_{\text{C}}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

# nert and and acuter of beloner od new tert RESISTIVE SWITCHING

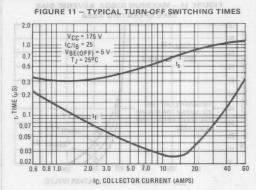
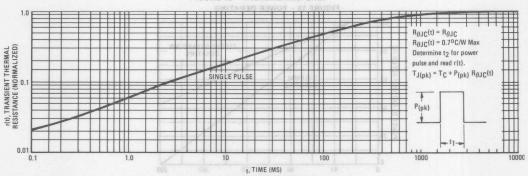
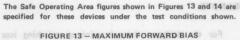
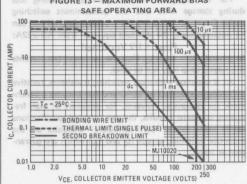


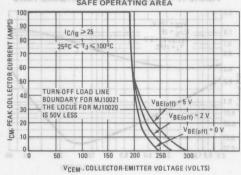
FIGURE 12 - THERMAL RESPONSE







# FIGURE 14 – MAXIMUM RBSOA, REVERSE BIAS



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

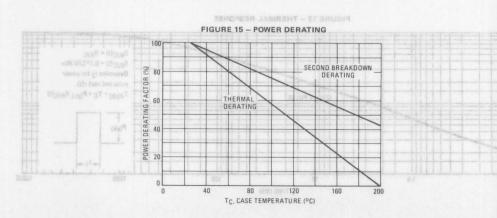
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^{\circ}$  C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

 $T_{J(pk)}$  may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.





## Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10022 and MJ10023 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Fast Turn-Off Times
   150 ns Inductive Fall Time @ 25°C (Typ)
   300 ns Inductive Storage Time @ 25°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for: Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents

#### **MAXIMUM RATINGS**

2.6 Rating 0.8	Symbol	MJ10022	MJ10023	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Emitter Voltage	VCEV	450	600	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	1	10	Adc
Base Current — Continuous — Peak (1) 0 800	I <sub>B</sub>		0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C	PD	the second second second	43	Watts
Derate above 25°C		1.	43	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W
Maximum Lead Temperature for Soldering	T <sub>L</sub>	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 40 AMPERE

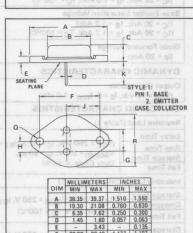
#### NPN SILICON POWER DARLINGTON TRANSISTORS

350 and 400 VOLTS 250 WATTS

# Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



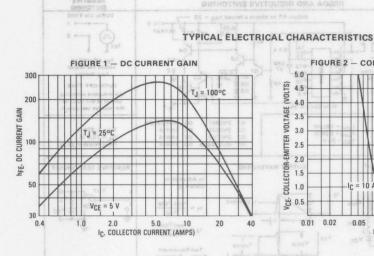


CASE 197-01 MODIFIED TO-3



VIGTOR	NPN SILICE POWER DARLIN TRANSISTO							ONPC	
	CHARACTERISTICS (TC = 25	°C unless	otherwi	se noted)	1237	0.712	111113-21	SAUT	1165
27.10	Characteristic	ō	enpise	Symbol	Min	ditac	Тур	Max	Unit
OFF CHARACTE	RISTICS	2	liuania i	ing in inductive	nation	o taw	epital, po	gs, high	for high-volta
Collector-Emitter (I <sub>C</sub> = 100 mA, I	Sustaining Voltage (Table 1) B = 0)	MJ10		V <sub>CEO(sus)</sub>	350 400	heyb. Sation	oritic <u>at</u> . T node <u>au</u> alia	m <u>e</u> is sv <u>ult</u> chi	Vdc flw Deserge-enil
	Current Value, V <sub>BE(off)</sub> = 1.5 Vdc) Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 15	0°C)		ICEV	_		Sontrols ors	0.25 5.0	Switching
Collector Cutoff C	Current CEV, RBE = 50 Ω, T <sub>C</sub> = 100°C)	*	1	ICER	-		2) Drivers	5.0	mAdc
Emitter Cutoff Cu (V <sub>EB</sub> = 2.0 V, I <sub>C</sub>	rrent ig noimmight sitt		-100	IEBO	-		a	175	mAdc
SECOND BRE	AKDOWN			(m/T)	0.25%	o ami	Storage T	evitoue	300 ns Ir
Second Breakdow	n Collector Current with Base For	ward Biase	d	IS/b	Ce es	28 -	See Figure		noitement a
Clamped Inductive	e SOA with Base Reverse Biased	114.4		RBSOA			See Figure	14	
ON CHARACT	ERISTICS (1)	P27 - 3		chan	Laurin	inches.	SOA with	bassiR l	no tovell
DC Current Gain (I <sub>C</sub> = 10 Adc, V <sub>C</sub>				hFE	50	1	with Indus	600	Saturati
1,000	Saturation Voltage			V <sub>CE(sat)</sub>			8	Carren	Vdc
(I <sub>C</sub> = 20 Adc, I <sub>B</sub>	; = 1.0 Adc)		-	CE(Sat)	_	-		2.2	
Ic = 40 Adc, IB	= 5.0 Adc) = 1.0 Adc, T <sub>C</sub> = 100°C)				_		_	5.0 2.5	
Base-Emitter Sat	The second secon			V <sub>BE(sat)</sub>		-		2.0	Vdc
(IC = 20 Adc, IE	Charles and the second			*BE(Sat)	_		_	2.5	XIMUM RAT
Diode Forward Vo	oltage	rioU	E.200	TLM VEGOTUM	tod	478	2.5	5.0	Vdc
DYNAMIC CH	ARACTERISTICS	NAA.	-	0.34	(ene)	030			lav samma sama
Output Capacitan (VCR = 10 Vdc,	Ice I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	2007		C <sub>ob</sub>	150	N N	-	600	pF.
THE RESERVE OF THE PARTY OF THE	CHARACTERISTICS	969		094	1 3	3	0.00	Coming O	100000 10000
Resistive Load (Ta	able 1)	at A	T	0.0	1 10			THE RESE	
Delay Time	A F XI	-		td	- 6	det	0.03	0.2	μς
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 20 A, I <sub>B1</sub> =	1.0 Adc,		n t <sub>r</sub>	1-7	9	0.4	1.2	solozicµS
Storage Time	$V_{BE(off)} = 5.0 \text{ V}, t_p = 50 \mu \text{s},$ Duty Cycle $\leq 2.0\%$			ENts	-		0.9001=	2.5	μς
Fall Time		D <sub>m</sub> /At		EA tf	-		0.3	0.9	Ad to μS of sta
Inductive Load, C	lamped (Table T)	30		-85 to +200	gla	T.I.	noi	romut, eg	rating and Store
Storage Time Crossover Time	(I <sub>CM</sub> = 20 A, V <sub>CEM</sub> = 250 V, I <sub>B1</sub>	= 1.0 A,	1	tsv	1=	-	0.6	2.0	μS
Fall Time	VBE(off) = 5 V, T <sub>C</sub> = 100°C)		-	t <sub>C</sub>		-	0.3	2.0	μS
Storage Time		25113	7.0	t <sub>sv</sub>			1.0	11.530.211	μS
Crossover Time	(I <sub>CM</sub> = 20 A, V <sub>CEM</sub> = 250 V, I <sub>B1</sub> V <sub>BE(off)</sub> = 5 V, T <sub>C</sub> = 25°C)	= 1.0 A,	1 5	t <sub>C</sub>	-		0.3	oltanul.	μs
Fall Time	«ВЕ(ОП) - 9 V, IC - 25 C)	30	8	s tfi I	+	9	0.15	enultined	meT ba µs mumi





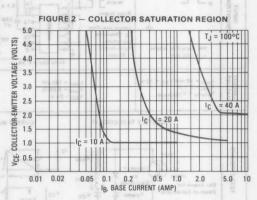
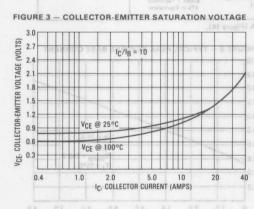
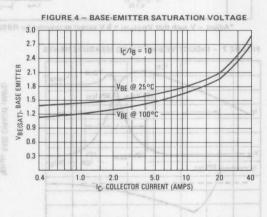
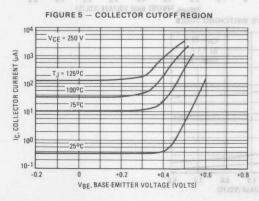
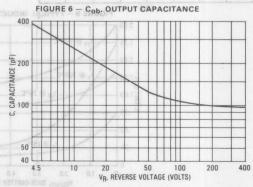


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

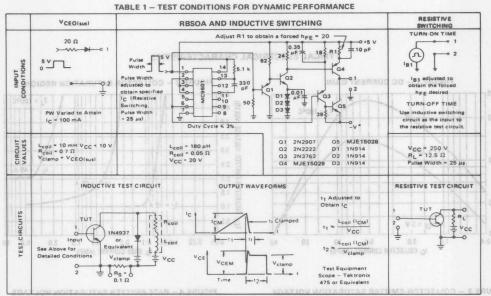




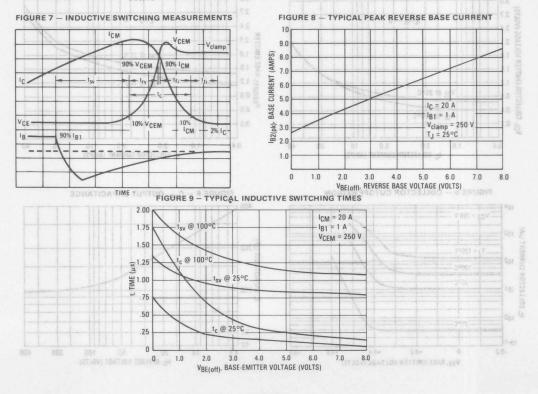












#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% VCEM

t<sub>rv</sub> = Voltage Rise Time, 10—90% V<sub>CEM</sub>

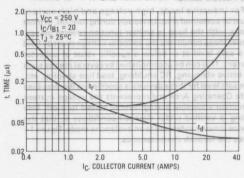
tfi = Current Fall Time, 90—10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform is shown in Figure 7 to aid on the visual identity of these terms.

FIGURE 10 - TYPICAL TURN-ON SWITCHING TIMES



For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:  $PSWT = 1/2 \ VCClC(t_C)f$ 

In general,  $t_{rv}$  +  $t_{fi} = t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user orinented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at  $100^{\circ}\text{C}$ .

FIGURE 11 - TYPICAL TURN-OFF SWITCHING TIMES

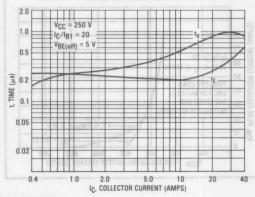
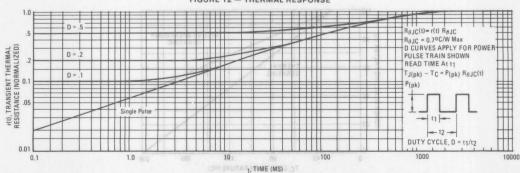
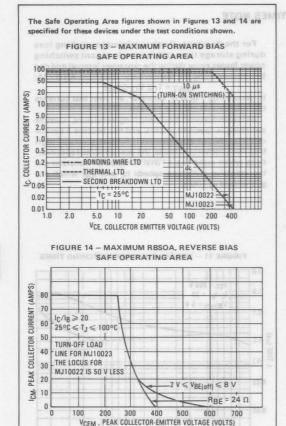


FIGURE 12 - THERMAL RESPONSE





#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

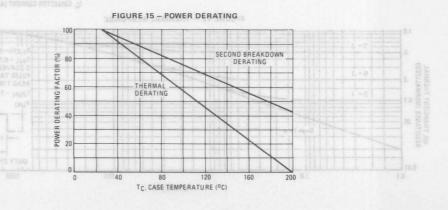
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

 $T_{J(pk)}$  may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAST WO WOUT JACKYT - OF BRUDIE

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.





# Designer's Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10024 and MJ10025 Darlington transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for:
   Reversed Biased SOA with Inductive Loads
   Switching Times with Inductive Loads
   Saturation Voltages
   Leakage Currents



#### **MAXIMUM RATINGS**

Rating	Symbol	MJ10024	MJ10025	Unit
Collector-Emitter Voltage	VCEO(sus)	750	850	Vdc
Collector-Emitter Voltage	VCEV	1000	1200	Vdc
Emitter Base Voltage	VEB	8	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>		10	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C	PD		50 43	Watts
Derate above 25°C		1.	43	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle  $\leqslant$  10%.

#### 20 AMPERE

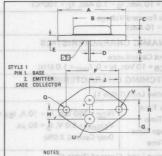
# NPN SILICON POWER DARLINGTON TRANSISTORS

750 and 850 VOLTS 250 WATTS

# Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.





NOTES:
1. DIMENSIONS Q AND V ARE DATUMS.
2. T. IS SEATING PLANE AND DATUM.
3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q.

♦ ♦.13 (0.005) ⊙ T V ⊚
FOR LEADS:

↑ 0.13 (0.005) ○ T V ○ Q ○ 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

DIM MIN MAX MIN MAX
A - 39.37 - 1.550
B - 21.08 - 0.830
C 6.55 - 152 - 0.550
D 0.97 1:09 0.038 0.043
C 1.40 1.78 0.055 0.070
F 30.15 85C 1.187 85C 0.275 0.070
F 30.15 85C 0.470 85C 0.470 85C
M 5.46 85C 0.470 95C
M 5.470 95C 0.470 95C
M 5.470 95C
M

**CASE 1-05** 

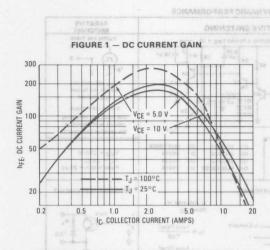
M110025

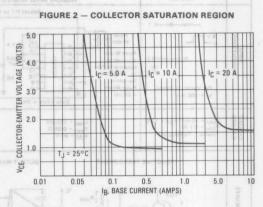
Maximum Lead Temperature for Soldering
Purposes 1/8" from Case for 5 Seconds
(1) Pulse Tee: Pulse Width = 5 ms, Ducy Cycle < 10%)

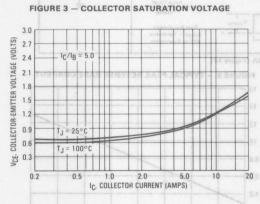
	Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTE	ERISTICS			0.70	inan a	massuotnes		
Collector-Emitter	Sustaining Voltage (Table 1) B = 0)	MJ1002	F-1 F-15-12	CEO(sus)	750 850	OWER DAR	O NOOL	Vdc
	- Current Value, V <sub>BE(off)</sub> = 1.5 Vdc) Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150	o°C) éang	iest an	ICEV a exotaians	t na <u>n</u> gai	MJ10 <u>0</u> 25 Dell	0.25 5.0	mAdc
Collector Cutoff ( (V <sub>CE</sub> = Rated V	Current CEV, RBE = 50 Ω, T <sub>C</sub> = 100°C)	tol b	2100	ICER	d ere	critical, They	5.0	mAdc
Emitter Cutoff Cu (V <sub>EB</sub> = 2.0 V, I <sub>C</sub>	CONTROL OF THE PROPERTY OF THE			IEBO	-	Controls	175	mAdc
SECOND BRE	AKDOWN					2101	ng Regula	manus 9
Second Breakdov	wn Collector Current with base for	ward biased		IS/b		See Figure 14		nanovni <del>o</del>
Clamped Inductiv	ve SOA with base reverse biased			RBSOA	1199	See Figure 15	t and Rela	e Solencia
ON CHARACT	TERISTICS (1)			0.0	057 OJ C	orure Ranga -	technal b	illeregO ®
DC Current Gain	riginab "assa tarew"		0	hFE she	50	de Spacified for 1 SOA With Indi	600	nevsh switch
(I <sub>C</sub> = 10 Adc, I <sub>E</sub> I <sub>C</sub> = 20 Adc, I <sub>B</sub>		I	-	V <sub>CE(sat)</sub>	=	2009 - 25 -	2.2 5.0 2.5	Tuta Vdc
Base-Emitter Sat (I <sub>C</sub> = 10 Adc, I <sub>E</sub> (I <sub>C</sub> = 10 Adc, I <sub>E</sub>		L		VBE(sat)	_	=	2.5 2.5	Vdc
Diode Forward Vo	oltage			Vf	-	1.25	4.0	Vdc
DYNAMIC CH	IARACTERISTICS							
Output Capacitar	Ice Ice 1.0 kHz)			C <sub>ob</sub>	110	-	500	pF
	CHARACTERISTICS			14 19 1			SDNU	AR MUMBA
Resistive Load (T	able 1)							
Delay Time	The same of	50nU - 1	****	t <sub>d</sub>	100	0.03	0.3	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A, I <sub>B1</sub> = 1		088	tr	(803)	0.6	1.8	1 1013/m2-1075/H
Storage Time	$V_{BE(off)} = 5.0 \text{ V}, t_p = 50 \mu \text{s},$ Duty Cycle $\leq 2.0\%$		1200	ts ooot	V3	2.0	5.0	Illector-Emiliter V
Fall Time		ODV		O.tf	- 8	0.6	1.8	hitter Basa Volta
100000	Clamped (Table 1)	Ada		20			- Continuo	Hector Current
Storage Time Crossover Time	(I <sub>CM</sub> = 10 A, V <sub>CEM</sub> = 250 V, I <sub>B1</sub> = V <sub>BE</sub> (off) = 5 V, T <sub>C</sub> = 100°C)	Adc		t <sub>c</sub>		2.9 1.0	7.0 3.3	υς Ourrent — Cr
Storage Time Crossover Time	(I <sub>CM</sub> = 10 A, V <sub>CEM</sub> = 250 V, I <sub>B1</sub> : R <sub>BE</sub> = 24 Ω, T <sub>C</sub> = 100°C	= 1.0 A,		t <sub>sv</sub>	= 0	9.0	50 25	μS
Storage Time Crossover Time	(I <sub>CM</sub> = 10 A, V <sub>CEM</sub> = 250 V, V <sub>BE</sub> I <sub>B1</sub> Baker Clamped [1 Ampere Sc			t <sub>sv</sub>	_	2.2 0.5	- 09	25 evµs's otano
X2.14 080.4	T <sub>C</sub> = 100°C)	30	90	74 D. GO-	(118	di ne	age dunch age	elating and \$19 femperature Rac
(1) Pulse Test: PV	V = 300 μs, Duty Cycle ≤ 2%						RACTER	IERMAL CHA
			Wax				naragtarist	

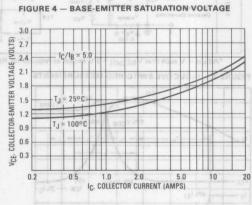
CASE 1-05

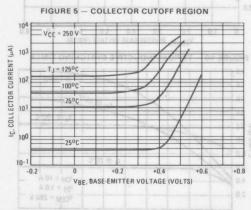












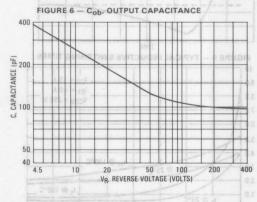
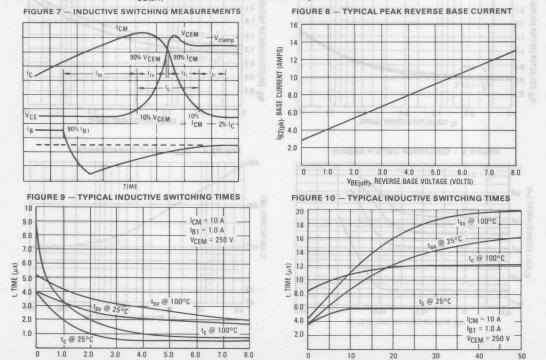




TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE RESISTIVE VCEO(sus) **RBSOA AND INDUCTIVE SWITCHING** SWITCHING Adjust R1 to obtain a forced hpE = 10 20 n A TA CONDITIONS 62 Width 14 IB1 adjusted to 012 7 330 pF adjusted to he desired obtain specified IC (Resistive Switching, D2 TURN-OFF TIME Use inductive switching circuit as the input to PW Varied to Attain Pulse Width = 25 μs) IC = 100 mA the resistive test circuit CIRCUIT L<sub>coil</sub> = 10 mH V<sub>CC</sub> = 10 V R<sub>coil</sub> = 0.7 Ω V<sub>clamp</sub> = V<sub>CEO(sus)</sub> Q1 2N2907 05 MJE15028 L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V Q2 2N2222 Q3 2N3762 Q4 MJE15029  $V_{CC}$  = 250 V  $R_L$  = 25  $\Omega$ Pulse Width = 25  $\mu$ s D1 D2 1N914 1N914 D3 1N914 INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to Obtain I<sub>C</sub> TEST CIRCUITS PL VCC TUT Vcc -0 Lcoil (ICM) See Above for **Detailed Conditions** V<sub>clamp</sub> VCE VCEM Test Equipment Scope - Tektronix 475 or Equivalent \*Adjust - V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).



RBE, BASE-EMITTER RESISTANCE (OHMS)

VBE(off), BASE-EMITTER VOLTAGE (VOLTS)

# SWITCHING TIMES NOTE Prompt and excellent and the state of the second state of the sec

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>CEM</sub>

t<sub>rv</sub> = Voltage Rise Time, 10—90% V<sub>CEM</sub>

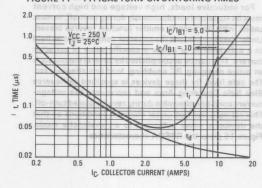
tfi = Current Fall Time, 90—10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform is shown in Figure 7 to aid on the visual identity of these terms.

FIGURE 11 — TYPICAL TURN-ON SWITCHING TIMES



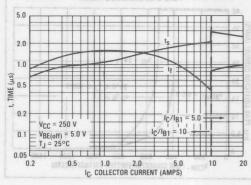
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

 $PSWT = 1/2 \ V_C C | C(t_C) f$  In general,  $t_{rv} + t_{fi} \cong t_C$ . However, at lower test currents this relationship may not be valid.

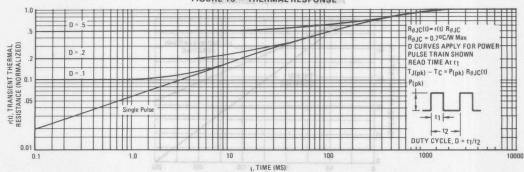
As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user orinented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $(t_{\text{C}}$  and  $t_{\text{SV}})$  which are guaranteed at  $100^{\circ}\text{C}$ .

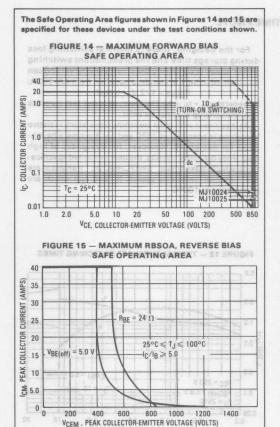
FIGURE 12 — TYPICAL TURN-OFF SWITCHING TIMES

5.0 10 20 50 100 260









# SAFE OPERATING AREA INFORMATION

# **FORWARD BIAS**

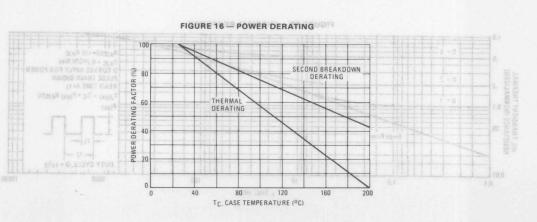
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 14 is based on  $T_C = 25^{\circ}\text{C}$ :  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \! \ge \! 25^{\circ}\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 14 may be found at any case temperature by using the appropriate curve on Figure 16.

 $T_{J(pk)}$  may be calculated from the data in Figure 13. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

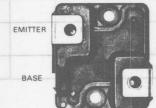




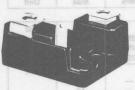
# Designer's Data Sheet

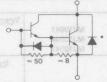
# 25 kVA ENERGY MANAGEMENT SERIES SWITCHMODE DARLINGTON TRANSISTORS 25, 50 and 100 Ampere Operating Current

These Darlington transistors are designed for industrial service under practical operating environments requiring fast switching speed for highly efficient systems operating at high frequency such as inverters, PWM controllers and other high frequency systems operating from 120, 230 and 460 V lines.



COLLECTOR





\*Emitter-Collector Diode is a fast recovery high power diode. Note: The 8 ohm resistor is not included in the MJ10044 and MJ10047.

# **MAXIMUM RATINGS**

Mechanical Ratings	10001	LIM
Rating	Value	Unit
Mounting Torque (To heat sink with 6-32 Screw) (Note 1)	8.0	inlb
Lead Torque (Lead to bus with 5 mm Screw) (Note 2)	20	inlb
Per Unit Weight A .05 .85 .85 .89 AOZ.JO	41	grams

# THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case, R <sub>BJC</sub> 0.5	°C/W
--	------

Mica Insulators available as separate items 0.003" thick. Motorola Part Number 14CSB12387B003.

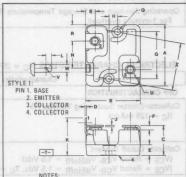
- 1. A Belleville washer of 0.281" O.D., 0.138" I.D., 0.013" thick and 43 pounds flat is recommended.
- 2. The maximum penetration of the screw should be limited to 0.50".
- 3. To adapt the collector and emitter terminals to quick connect terminals, AMP 250 Series Faston tab P/N 61499-1 is suggested.
- 4. The mounting holes of this package are compatible with TO-204 (formerly TO-3) mounting holes.

# 25, 50, and 100 AMPERE **NPN SILICON POWER DARLINGTON TRANSISTOR**

250, 450 and 850 VOLTS **250 WATTS** 

#### Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst-case" design.



- - 1. DIMENSIONS A AND B ARE DATUMS AND T IS BOTH A DATUM SURFACE AND SEATING PLANE.
- 2. POSITIONAL TOLERANCE FOR MOUNTING HOLES:
- HOLLES:

  ## # 0.25 (0.010) T A B B

  3. DIMENSIONING AND TOLERANCING PER
  ANSI Y14.5, 1982.

  4. CONTROLLING DIMENSION: INCH
  EXCEPT FOR METRICALLY THREADED

12 0	MILLI	WETERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
As	39.11	40.13	1.540	1.580
В	33.93	34.95	1.336	1.376
C	1201	20.32	Resid	0.800
D	0.68	0.83	0.027	0.033
E	8.30	8.81	0.327	0.347
F	3-0:	4:44	0401	0.175
G	29.67	BSC	1.168 BSC	
H	5.08	BSC	0.200 BSC	
J	0.93	1.09	0.037	0.043
K	-	25.40	-	1.000
L	2.92	3.30	0.115	0.130
N	17.14	17.39	0.675	0.685
0	3.73	3.88	0.147	0.153
R	10.41	10.79	0.410	0.425
S	5.84	6.35	0.230	0.250
U	M5	.8 (MET	RIC TH	RD)
٧	1.27	1.52	0.050	0.060
W	4.69	4.85	0.185	0.191
X	30.1	5 BSC	1.18	7 BSC

3839MA 991 bos Rating		Symbol	MJ10041	MJ10044	MJ10047	Unit
Collector-Emitter Voltage (I <sub>B</sub> = 0)		VCEO	850	450	250	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)		VCER	900	500	300	Vdc
Collector-Base Voltage		VCB	900	500	300	Ma Vdc
Emitter-Base Voltage		VEB	Operating	910 8.0 A 00	37 bns 08 ,	Vdc
Collector Current — Operating	$(T_C = 115^{\circ}C)$ $(T_C = 85^{\circ}C)$ $(T_C = 85^{\circ}C)$	ng fast sw	101 t 25 alsel	50		
Collector Current — Continuous — Peak Repetitive — Peak Nonrepetitive	cy sys-	inulCit di	37.5 75 125	75 150 250		
Base Current — Continuous — Peak Nonrepetitive		ΙΒ	6	25 50	À	А
Total Device Dissipation  Derate above T <sub>C</sub> = 25°C  For 1-minute overload		PD		250 2.0 333	EMITTER	Watts W/°C Watts
Operating Junction and Storage Temperature Ra For 1-minute overload	nge	T <sub>J</sub> , T <sub>stg</sub>	- Albert	-55 to +150 -55 to 200	7740	°C

ELECTRICAL	CHARACTERIS	TICS (TC =	25°C unless	otherwise	noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	9		40	- 0	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 125 mAdc)	MJ10041 MJ10044 MJ10047	VCEO(sus)	850 450 250	Ξ	Vdc
Collector Cutoff Current (VCE = Rated VCB, VBE(off) = 1.5 Vdc) (VCE = Rated VCB, VBE(off) = 1.5 Vdc, TC = 150°C	0.00	ICEV	Collection D	2.0	mA
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CER</sub> , R <sub>BE</sub> = 10 Ω, T <sub>C</sub> = 100°C)	9901LM bns \$5001LM er	ICER	on e <del>l n</del> otelas	and10 ed7	.e.o mA
Emitter Cutoff Current (VEB = 4.0 Vdc, I <sub>C</sub> = 0)	MJ10041 MJ10044 – MJ10047	IEBO	=	500 2.5	mA
	di-ni I 0.8	ficience	SE-6 HEW	TTO ROST SINS	sample I on

# SAFE OPERATING AREA

Second Breakdown Collector Current with Base F	orward-Biased		FBSOA	See F	igures 32, 3	4 & 36	hora I
Clamped Inductive SOA with Base Reverse-Biase	d		RBSOA	See F	igures 33, 3	5 & 37	(6)
Overload Safe Operating Area	grame	18	OLSOA	See Figure	s 38, 39, 40,	41, 42 & 43	109
DYNAMIC CHARACTERISTICS				10.3	TERSTOA	RMAL CHAP	aur
Output Capacitance	V4.07	6.0	Cob	Care. Ray	2000	pF	There

# DYNAMIC CHARACTERISTICS

Output Capacitance	Cob	Cast. Raid	2000	pF
$(V_{CB} = 10 \text{ Vdc}, I_{E} = 0, f_{test} = 1.0 \text{ kHz})$		Actual Control of the	Topono as Al-la	annial contains

<sup>(1)</sup> Pulse Test. Pulse width of 300 µs, duty cycle ≤ 2.0%.
\*This rating is with a 50% duty cycle, and is limited by power dissipation. Higher operating currents are allowable at lower duty cycles.

Fall Time

Crossover Time

Crossover Time

Storage Time

Inductive Load, Clamped Storage Time

(I<sub>CM</sub> = 25 A, VCEM = 300 V, VBE(OFF) = 5.0 V, I<sub>B1</sub> = 2.5 A)

TINU	Charac	teristic	lodding?		Symbol	Min	Max	Unit
ON CHARACTER	RISTICS (1)					STICS	HARLOTER	интеннив с
			MJ1	0041				
DC Current Gain					hFE			bood syltnies
	V <sub>CE</sub> = 5.0 Vdc) V <sub>CE</sub> = 10 Vdc)		67	A VR.F	rol 6.03 -	25 40		amiT yals
Collector-Emitter	Saturation Voltage				VCE(sat)	F) = 8.0 V. I	HOISEV	Vdc
(Ic = 25 Adc,						(200.5 = alpha)		erege fime
	$I_B = 7.5 \text{ Adc}$ $I_B = 2.0 \text{ Adc}, T_C = 10$	00°C)					5.0	H. Time
Base-Emitter Sat					V <sub>BE</sub> (sat)		beginsil	Vdc
(I <sub>C</sub> = 25 Adc,					DE(Sat)	-50 A	3.0	orage Time
	IB = 2.0 Adc, TC = 10	00°C)				= 250 V.	3.0	ossover Time
	1.5 3.8		MJ1	0044		,V 0.8 - pg	Vee(or	emil egste
DC Current Gain	0.5 1.5	_	22		hFE	IA XO.	. 191	ossovar Tana
(I <sub>C</sub> = 50 Adc,	V <sub>CE</sub> = 5.0 Vdc)					50	-	
(I <sub>C</sub> = 50 Adc,	V <sub>CE</sub> = 10 Vdc)					60		
Collector-Emitter	r Saturation Voltage				VCE(sat)			Vdc
	IB = 1.67 Adc)				-1 4 007	1 1507 ADV	2.0	emiT yels
	I <sub>B</sub> = 6.0 Adc) I <sub>B</sub> = 1.67 Adc, T <sub>C</sub> = 1	100°C)			= 100 A, lgr = 50 as.	180 Vets 10	3.3	se Time
	U.S		- 0			12.0.2 × 810	O VIVO	V-1-
Base-Emitter Sat	I <sub>B</sub> = 1.67 Adc)				VBE(sat)		3.0	Vdc
	IB = 1.67 Adc, T <sub>C</sub> = 1	100°C)					3.0	ductive Loud.
ец	2.0 8.0		MJ1	10047				orage Time
DC Current Gain	0.0 0.1		of le		hee	100 A,	1910 <sup>17</sup>	egiT revoseo
	, VCE = 5.0 Vdc)					75	MBDV L	smiT egato
(I <sub>C</sub> = 100 Add	, V <sub>CE</sub> = 10 Vdc)		, AS <sub>1</sub>	T <sub>J</sub> = 25°C		90	= 18T	min agaio
Collector-Emitte	r Saturation Voltage				VCE(sat)			Vdc
	, I <sub>B</sub> = 2.75 Adc)					_8397	2.0	HD 30010 3-
(I <sub>C</sub> = 100 Add	, I <sub>B</sub> = 2.75 Adc, T <sub>C</sub> =	100°C)	- 69				2.5	ower Dissiper
Base-Emitter Sa					V <sub>BE</sub> (sat)	(60 Hz)	иев Сиген	Vdc
and the second	;, IB = 2.75 Adc)	100°C)				_	3.5	orward Volum
	, I <sub>B</sub> = 2.75 Adc, T <sub>C</sub> =			16001131			1	11A 30 - 30
(1) Pulse Test: Pul	se width of 300 μs, duty of	cycle ≤ 2.0%.						
								(lp = 100 Ad
ELECTRICAL (	CHARACTERISTICS	(Continued) (T	C = 25°C ur	nless otherwis	e noted.)	(a <sub>M</sub> \A		sverse Recovi (lg = 25 Adc
	Characterist	ic		Symbol	Min	Тур	Max	Unit
SWITCHING CH	ARACTERISTICS			1800103		(100/21 W)	10/10/10	37 901 - 411
* 1	3.5 12.5		MJ	10041		(aii)	Daily Contracts	verde Recove
Resistive Load	10 25	- 1	of the King	14007LM			irds = 50 A	
Delay Time	00 85			td		0.03	0.25	μs
Rise Time	(VCC = 300 Vdc, Ic	= 25 A, IR1	= 2.5 A,	- 47	naz = aban	1.2	5.0	Trul briswice
	$V_{BE(OFF)} = 5.0 \text{ V},$			rantras.			-	0p = 26 A 4c
Storage Time	Duty Cycle ≤ 2.0%			t <sub>S</sub>	-	3.3	10	(lp = 80 Ado
Fall Time	The second second			te		1.5	5.0	bA = 001 = at

ELECTRICAL CHARACTERISTICS (Continued) (T<sub>C</sub> = 25°C unless otherwise noted.)

 $T_J = 100^{\circ}C$ 

 $T_J = 25^{\circ}C$ 

tf

tsv

tc

tsv

 $t_{\text{C}}$ 

1.5

5.0

3.0

3.5

1.5

5.0

15

10

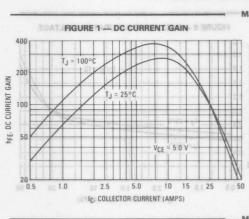
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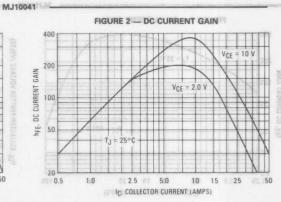
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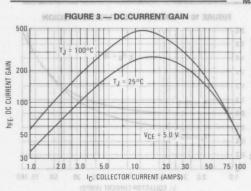
μs

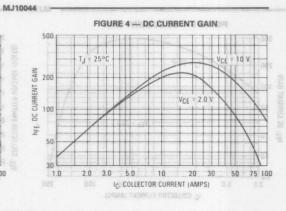
HnU	Max	Characteristic	Symbol		Symbol	Min	Тур	Max	Unit
SWITCHING CHA	RACTER	ISTICS						(r) SOTTE	CHARACTER
				MJ10	0044				
Resistive Load			ned						Current Gain
Delay Time	-	25		1 . 7 . 1 . 2 . 3	td	_	0.03	0.25	μς
Rise Time	(Vcc =	250 Vdc, IC	= 50 A, IB	= 1.67 A,	t <sub>r</sub>		0.9	3.0	10 A 82 = 0
Storage Time		FF) = 5.0  V, t	$p = 50 \mu s$ ,		ts	_	1.5	3.8	lector-Emilter c = 25 Adc. I
Fall Time	Duty C	ycle ≤ 2.0%)			tf	_	0.4	1.3	c = 25 Adc. i c = 37.5 Adc
Inductive Load, C	lamnad				4	(310	30, 10 = 10	W N.2 = 8	30A 65 = 5
Storage Time	lampea		(182)36 (		t <sub>sv</sub>		2.5	7.5	1162 1831111 <u>2</u> 8
Crossover Time	(ICM =			$T_J = 100^{\circ}C$		27970	0.8	3.0	C = 25 Α (c. 1
		= 250  V, FF) $= 5.0 \text{ V},$		2.50	tc	10/0	1.5	3.8	1 138W dz - 3
Storage Time	IB1 =			$T_J = 25^{\circ}C$	t <sub>SV</sub>		0.5		-/
Crossover Time		108	34n	2010	t <sub>c</sub>		0.5 (ab)/	1.5	Current Sein
		09		MJ1	004/		(ob)v	Of - 30	( abA 33 - 3
Resistive Load			Voctest)				- Voltage	piterure 5	noting a robust
Delay Time	2.0	150 Vdo 1-	- 100 A I-	- 275 A	td	-	0.035	0.25	Δgμs
Rise Time		= 150  Vdc, IC = 5.0  V, t		31 = 2.75 A,	t <sub>r</sub>	-	1.2	4.0	c = 76  Adc, I $c = 80  Adc, I$
Storage Time		ycle ≤ 2.0%)			t <sub>S</sub>	-	1.4	4.0	o-Emitter pap
Fall Time	0.2		V8E(set)		tf	_	0.25	1.0	Laha OR = 5
Inductive Load, C	lamped	-				(3,00	lde, Tc = 1	g = 1.67 /	c = 50 Ade, i
Storage Time	(Icaa =	100 A,		T.1 = 100°C	t <sub>sv</sub>	_	2.8	8.0	μs
Crossover Time		= 150 V,	394		t <sub>c</sub>	_	1.4	4.0	Current Gain
Storage Time		FF) = 5.0  V,		T,j = 25°C	t <sub>sv</sub>		2.2	6.5	cbA 001 = 5
Crossover Time	IB1 =	2.75 A)		.3	t <sub>C</sub>	_	1.0	3.0	000 001 = 3
C-E DIODE CHAP	RACTERIS	STICS	(188)207				Ada)	lo = 2.75	c = 100 Ade.
Power Dissipation	n (IB = 0	))			PD	49'007	= oT_dbA	125	c W 100 Ade,
Single Cycle Surg	ge Currer	nt (60 Hz)	VBE(set)	No. of the Co.	IFSM	_	_agmi	V 250	Apk
Forward Voltage	(1)	946	Py. FIE		VF	2000000	follow	Gr2 = 8)	Vdc
(IF = 25 Adc)				MJ10041	-	(0"00"	2.7	5.0	ob/ 001 400
$(I_F = 50 \text{ Adc})$ $(I_F = 100 \text{ Adc})$				MJ10044 MJ10047		10.0 The 410?	1.7	5.0 5.0	Pulsa Test Puls
Reverse Recover	Time			1013 10047			2.0	5.0	
(IF = 25 Adc, c		5 A/μs)		MJ10041	trr	(per <del>se</del> itne)	0.2	TOA 1.0	μS ECTRICAL C
(IF = 50 Adc, c	di/dt = 50	0 A/μs)		MJ10044		- ,	0.4	1.0	
(I <sub>F</sub> = 100 Adc,				MJ10047	100000000000000000000000000000000000000		0.4	1.0	HO CHILLDON
Reverse Recover				MJ10041	IRM(rec)		3.5	12.5	A
$(I_F = 25 \text{ A}, \text{ di/d})$ $(I_F = 50 \text{ A}, \text{ di/d})$				MJ10041	-		10	25	band suitals
(IF = 100 A, di				MJ10047	-		25	50	
Forward Turn-On	Time (C	ompliance Vo	oltage = 25		ton	= 25 A, lgq	300 Vdc. le	- savi	μs
(IF = 25 Adc)		E.E.		MJ10041		,au 00 = g	V 0.1	1.0	90001-8
(IF = 50 Adc) (IF = 100 Adc)		0.0		MJ10044 MJ10047			0.1	0.5	emiT egen
(1) Pulse Test: Puls	26-11-11-11	300 μs. duty c	vcle ≤ 2.0%	711010047			0.4		omil:
			, 5.5 ~ 2.076.						
					TJ = 100°C			- MOD -	

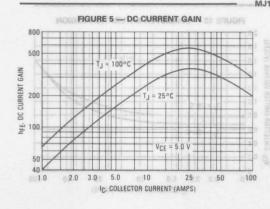
# TYPICAL ELECTRICAL CHARACTERISTICS

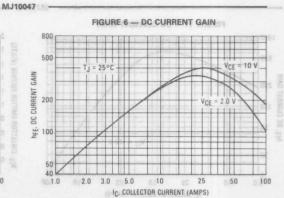






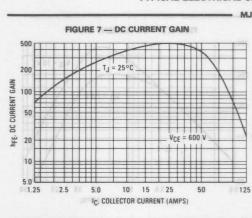


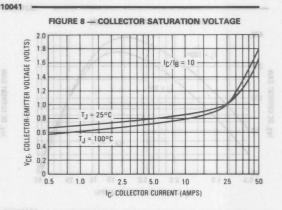


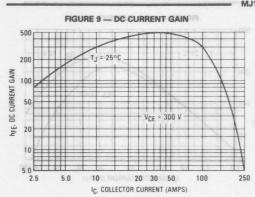


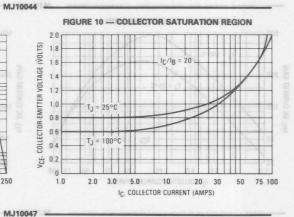
3-859

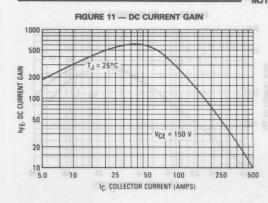
# TYPICAL ELECTRICAL CHARACTERISTICS (continued)

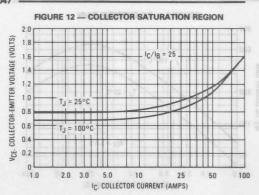




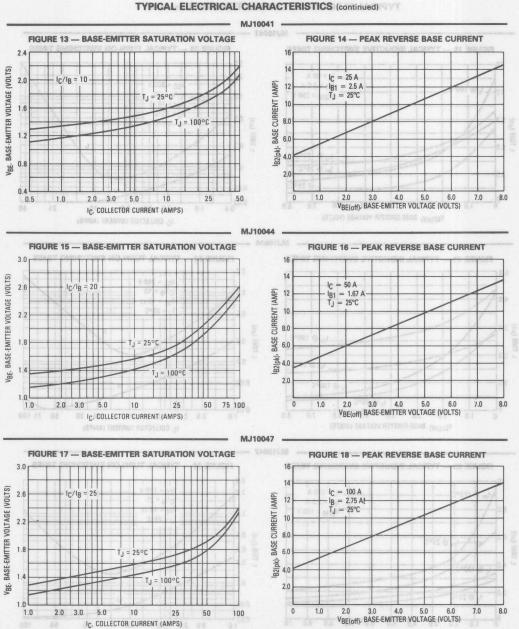




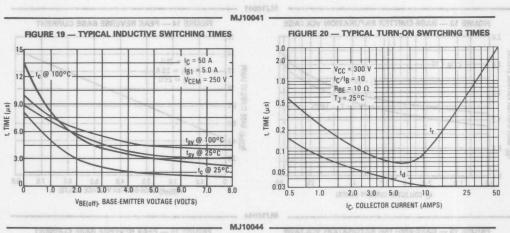


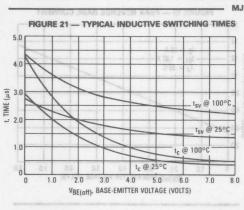


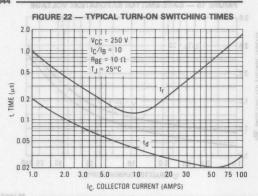
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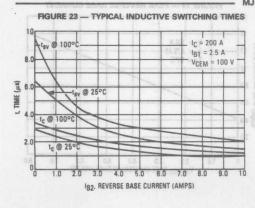


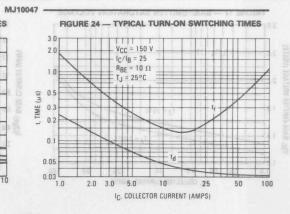
# TYPICAL ELECTRICAL CHARACTERISTICS (continued)





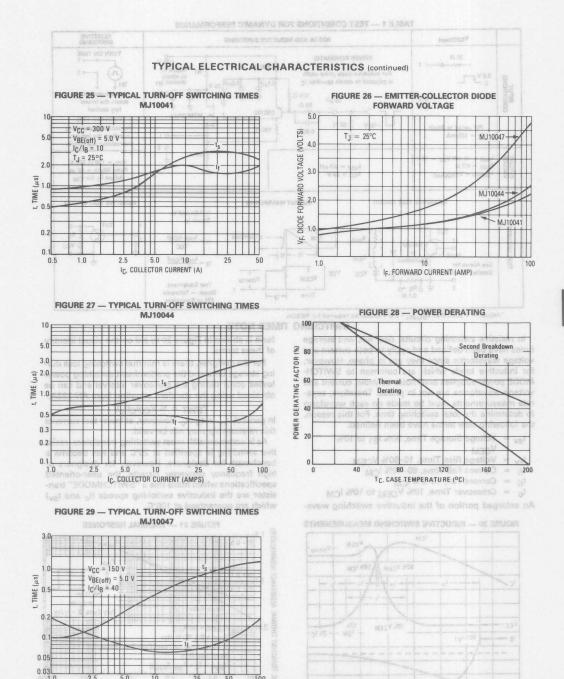






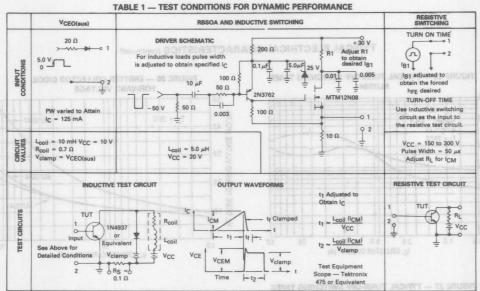
3





IC, COLLECTOR CURRENT (A)





\*Adjust - V such that VBE(off) = 5.0 V except as required for RBSOA

# **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCH-MODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10%

VCEM

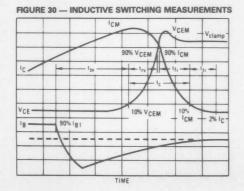
t<sub>rv</sub> = Voltage Rise Time, 10-90% V<sub>CEM</sub>

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching wave-



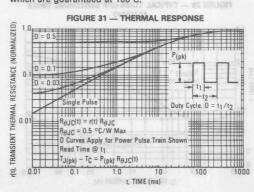
form is shown in Figure 30 to aid on the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

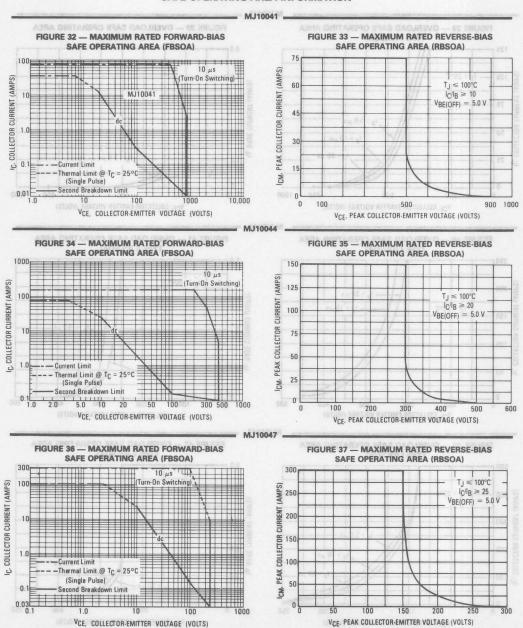
PSWT = 1/2 VCCIC(tc)f

In general,  $t_{\text{TV}} + t_{\text{fi}} \simeq t_{\text{C}}$ . However, at lower test currents this relationship may not be valid.

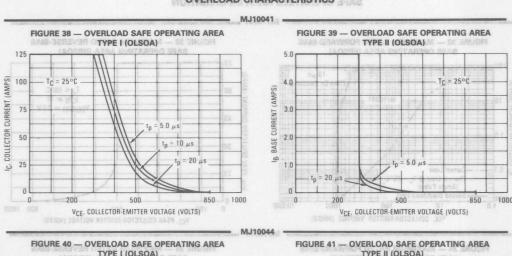
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

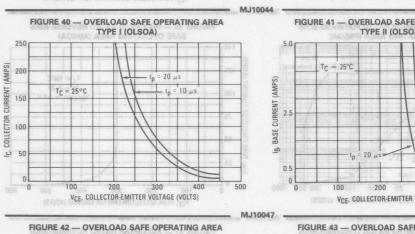


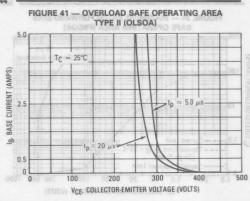
# SAFE OPERATING AREA INFORMATION

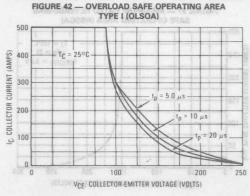


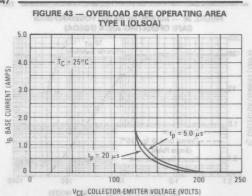
# OVERLOAD CHARACTERISTICS











## SAFE OPERATING AREA INFORMATION

# FORWARD BIAS

There are two limitations on the power handling ability of a transitor: average junction temperature and second breakdown. Safe operating area curves indicate IC — VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 32, 34, and 36 are based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25$ °C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on these figures may be found at any case temperature by using the appropriate curve on Figure 28.

 $T_{J(pk)}$  may be calculated from the data in Figure 31. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figures 33, 35 and 37 give the RBSOA characteristics.

# **OVERLOAD SAFE OPERATING AREA**

The forward-bias safe operating area (FBSOA) specification given in these figures adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

# TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figures 38, 40 and 42 depict the Type I OLSOA rating for these devices. Maximum allowable collector-emitter voltage versus collec-

tor current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, these figures define the maximum time which can be allowed for fault detection and shutdown of base drive.

MJ10041, MJ10044, MJ10047

Type I OLSOA is measured in a common-base circuit (Figure 44) which allows precise definition of collectoremitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

# **TYPE II OLSOA**

Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

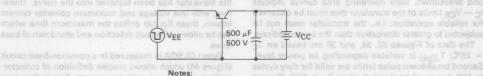
This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collector-emitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as shown in Figures 39, 41 and 43 are measured in the circuit shown in Figure 45, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NON-REPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for these devices is 100 occurrences. Another factor is the form of turn-off bias. For these devices, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from IB2 = 0 (soft) to VBE(off) = 5.0 V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.

# OVERLOAD SAFE OPERATING TEST CIRCUITS

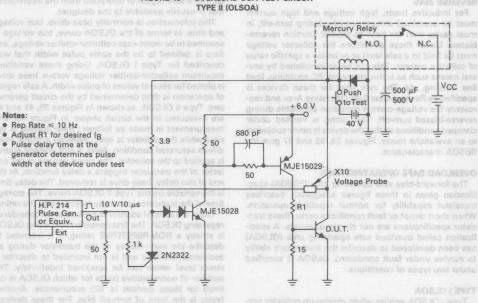
# ealury) Lerbb w setup treves not in FIGURE 44 — OVERLOAD SOA TEST CIRCUIT -not that arit network get arriver as temporary to the control of the control of



# VCE = VCC + VBE

 Adjust pulsed current source sparloy off is making ald well A soulistimil is in for desired I<sub>C</sub>, t<sub>p</sub>

# FIGURE 45 — OVERLOAD SOA TEST CIRCUIT



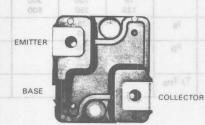
3

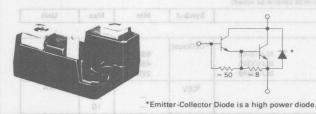


# Designer's Data Sheet

# 25 KVA ENERGY MANAGEMENT SERIES SWITCHMODE DARLINGTON TRANSISTORS 25, 50 and 100 Ampere Operating Current

These Darlington transistors are designed for industrial service under practical operating environments found in switching high power inductive loads off 120, 230 and 460 Volt lines.





# **MAXIMUM RATINGS**

Mechanical Ratings		
Rating	Value	Unit
Mounting Torque (To heat sink with 6-32 Screw) (Note 1)	8.0	inlb
Lead Torque (Lead to bus with 5 mm Screw) (Note 2)	20	inlb
Per Unit Weight 14 .05 .82 .85 emugh es2 A02.40	41	grams

# THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case, Rajc °C/W

Mica Insulators available as separate items. 0.003" thick. Motorola Part Number 14CSB12387B003.

# Notes:

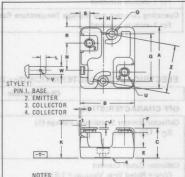
- 1. A Belleville washer of 0.281" O.D., 0.138" I.D., 0.013" thick and 43 pounds flat is recommended.
- 2. The maximum penetration of the screw should be limited to 0.50".
- 3. To adapt the collector and emitter terminals to quick connect terminals, AMP 250 Series Faston tab P/N 61499-1 is suggested.
- 4. The mounting holes of this package are compatible with TO-204 (formerly TO-3) mounting holes.

# 25, 50, and 100 AMPERE NPN SILICON POWER DARLINGTON TRANSISTOR

250, 450 and 850 VOLTS **250 WATTS** 

# Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit datarepresenting device characteristics boundaries—are given to facilitate "worst-case" design.



- 1 DIMENSIONS A AND B ARE DATUMS AND T IS BOTH A DATUM SURFACE AND SEATING PLANE.
- 2. POSITIONAL TOLERANCE FOR MOUNTING HOLES:
- # Ø 0.25 (0.010) M T AM BM

  3. DIMENSIONING AND TOLERANCING PER
- ANSI Y14.5, 1982. 4. CONTROLLING DIMENSION: INCH EXCEPT FOR METRICALLY THREADED

	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	39.11	40.13	1.540	1.580	
В	33.93	34.95	1.336	1.376	
C	DEST	20.32	DAH	0.800	
D	0.68	0.83	0.027	0.033	
E	8.30	8.81	0.327	0.347	
F	ne o	4.44		0.175	
G	29.67	BSC	1.168 BSC		
H	5.08	BSC	0.200 BSC		
J	0.93	1.09	0.037	0.043	
K	-	25.40	2.0	1.000	
L	2.92	3.30	0.115	0.130	
N	17.14	17.39	0.675	0.685	
0	3.73	3.88	0.147	0.153	
R	10.41	10.79	0.410	0.425	
S	5.84	6.35	0.230	0.250	
U	M5	.8 (MET	RICTH	RD)	
V	1.27	1.52	0.050	0.060	
W	4.69	4.85	0.185	0.191	
X	30.1	5 BSC	1.18	7 BSC	

CASE 353-01

Rating	*00000000000000000000000000000000000000	Symbol	MJ10042	MJ10045	MJ10048	Unit
Collector-Emitter Voltage (I <sub>B</sub> = 0)		VCEO	850	450	250	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	8	VCER	900	500	300	Vdc
Collector-Base Voltage	SAI	V <sub>CB</sub>	900	500	300	Vdc
Emitter-Base Voltage		VEB	marado a	8.0	L WILL DO U	Vdc
Collector Current — Operating	(T <sub>C</sub> = 115°C) (T <sub>C</sub> = 85°C) (T <sub>C</sub> = 85°C)	C(op) to	ban25 eb s	50	100*	These Did
Collector Current — Continuous — Peak Repetitive — Peak Nonrepetitive		IC	37.5 75 125	75 150 250	100 300 500	А
Base Current — Continuous — Peak Nonrepetitive		IB	( all	25 50		А
Total Device Dissipation  Derate above T <sub>C</sub> = 25°C  For 1-minute overload		PD		250 2.0 333	NS) TIME	Watts W/°C Watts
Operating Junction and Storage Temperature Re For 1-minute overload	ange	T <sub>J</sub> , T <sub>stg</sub>		-55 to +150 -55 to 200	BASE	°C

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS			ud.	- No	vin.
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 125 mAdc)	MJ10042 MJ10045 MJ10048	VCEO(sus)	850 450 250	_ 	Vdc
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	o Diude Is a high power diada	ICEV	minia*_	2.0	mA
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CER</sub> , R <sub>BE</sub> = 10 Ω, T <sub>C</sub> = 100°C)		ICER	-	10	YAS MA
Emitter Cutoff Current (VEB = 4.0 Vdc, IC = 0)	yiriU oufaV	IEBO	-	350	mA
The state of the s	dia - na	- Janes	200 00 B day	a deia tenul	ATT ALLESSAT INST

# SAFE OPERATING AREA

Second Breakdown Collector Current with Base Forward-Biased	FBSOA	See Figures 32, 34 & 36
Clamped Inductive SOA with Base Reverse-Biased	RBSOA	See Figures 33, 35 & 37
Overload Safe Operating Area	OLSOA	See Figures 38, 39, 40, 41, 42 & 43

# DYNAMIC CHARACTERISTICS

Output Capacitance		Cob	Case_Byjc	2000	pF
(VCB = 10 Vdc, IE = 0, ftest = 1.0 kHz)					

<sup>(1)</sup> Pulse Test. Pulse width of 300 µs, duty cycle ≤ 2.0%.

\* This rating is with a 50% duty cycle; and is limited by power dissipation. Higher operating currents are allowable at lower duty cycles.

(lp = 25 Adc) (lp = 50 Adc)

Unit	Mex	Charac	teristic	Symbol		Symbol	Min	Max	Unit
ON CHARACTE	RISTICS (	1)					Ristids	HARACTE	э амиотим
				MJ1	0042				
DC Current Gain						hFE			baod svicelaa
(IC = 25 Adc, V		tc) 800			2.0 A	757755	35	apVI	elay Time
(IC = 25 Adc, V	CE = 10 Vd	(2				380	40	= apR	ise Time
Collector-Emitter	Saturation	Voltage		3		V <sub>CE(sat)</sub>	Sycle ≤ 2.0%)	Lynu0 -	Vdc
(IC = 25 Adc, IE	3 = 2.0 Adc)	0.0				o=(out)		2.0	-
(I <sub>C</sub> = 37.5 Adc,							_	5.0	ductive Load.
(I <sub>C</sub> = 25 Adc, I <sub>B</sub>	3 = 2.0 Adc,	$T_{C} = 100^{\circ}C$	1995	vel	53552 5		- x 20	2.5	mmiT episoli
Base-Emitter Sat	turation Vol	Itage				V <sub>BE(sat)</sub>	= 350 V. Resd	Wany	Vdc
(I <sub>C</sub> = 25 Adc, I <sub>E</sub>				No.			-(A 0.9	3.0	emil agetol
(I <sub>C</sub> = 25 Adc, I <sub>E</sub>	3 = 2.0  Adc,	T <sub>C</sub> = 100°C		1 0 1				3.0	rossover fine
				MJ1	0045				
DC Current Gain						hFE			pact evintae
(I <sub>C</sub> = 50 Adc, V		dc) 80.0			1.67 A.	50 A. Jg 1	50	33VT	elay Time
(IC = 50 Adc, V					JA 1911	- IBI W OC	60	00%1	iso Time
Collector-Emitter	Saturation	Voltage		91		V <sub>CE(sat)</sub>	yele ≤ 2.0%	VING -	Vdc
(IC = 50 Adc, Ip						· CE(Sat)		2.0	Vac III
(IC = 75 Adc, Ip							_	3.3	ductive Lond.
(IC = 50 Adc, IE	3 = 1.67 Ad	c, T <sub>C</sub> = 100°	C)				-	2.5	torage Time
Base-Emitter Sat	turation Vol	Itage	-	J 9	2.001 - 61	V <sub>BE(sat)</sub>	= 250 V. Res	MID!	Vdc
(I <sub>C</sub> = 50 Adc, I <sub>E</sub>	3 = 1.67 Ad	c) 01				52(001)	TA YAT	3.0	orage Time
(I <sub>C</sub> = 50 Adc, I <sub>E</sub>	3 = 1.67 Ad	c, T <sub>C</sub> = 100°	C)				-	3.0	amiT tavosata
				MJ1	0048				
DC Current Gain						hee			pegul evizataa
(I <sub>C</sub> = 100 Adc,	VCF = 5.0 \	/dc) 800					75	_	elay Time
(I <sub>C</sub> = 100 Adc,	VCE = 10 V	dc)			= 2.76 A.	100 A. 461	90	Tyce	emiT sei
Collector-Emitter	Saturation	Voltage		a <sup>1</sup>		V <sub>CE(sat)</sub>	ycle ≤ 2.0%)	yrud	Vdc
(IC = 100 Adc,						CL(Sat)	_	2.0	entil be
(I <sub>C</sub> = 100 Adc,	IB = 2.75 A	dc, T <sub>C</sub> = 100	°C)					2.5	distribution Load.
Base-Emitter Sat	turation Vol	Itage		uni	2°007 = LT	V <sub>BE(sat)</sub>	4 000		Vdc so
(I <sub>C</sub> = 100 Adc,	dc, I <sub>B</sub> = 2.75 Adc)					0.01=	100 A. = 150 V. Rei	3.0	emil revessor
(I <sub>C</sub> = 100 Adc,	$I_B = 2.75 A$	dc, T <sub>C</sub> = 100	°C) -			1101-	76.353	3.0	iorage Time
(1) Pulse Test: Puls	se width of 3	00 us duty cyc	le < 2.0%	1 3					Eurit Jakosson
,									
				d <sub>d</sub>					
Apk								ga Current	
									orward Valtage
					MJ10042				
	8.1				31001 FW				
							(de = 25 A/µs)		

	Characteristi	c federale		Symbol	Min	Тур	Max	Unit
SWITCHING CH	ARACTERISTICS					(7)	TERISTICS	DARAHO
		1	MJ100	142				
		-	1010100	ITEM				
Resistive Load		9.74					e e	Current G
Delay Time	(V <sub>CC</sub> = 300 Vdc, I <sub>C</sub>	= 25 A lp1 =	20 A	td	_	0.03	0.25	μS
Rise Time	$R_{BE} = 10 \Omega$ , $t_{D} = 50$		2.0 / 1,	t <sub>r</sub>	_	1.2	5.0	
Storage Time	Duty Cycle ≤ 2.0%)			ts		35	100	ector-Ende
Fall Time	0.0	(18693)		tf	_	8.5	35	mba 22 = -
Inductive Load, (	Clamped							
Storage Time	2.8			t <sub>sv</sub>		50	150	μS
Crossover Time	(I <sub>CM</sub> = 25 A,	1	T <sub>J</sub> = 100°C	t <sub>c</sub>	_	20	60	Tanking a
Storage Time	VCEM = 350 V, RBI	= 10 Ω,  -		t <sub>sv</sub>	_	35	100	
Crossover Time	I <sub>B1</sub> = 2.0 A)		T <sub>J</sub> = 25°C	t <sub>C</sub>	-	10	35	
	Marie American		88.14.00			0 001 5 11 0	1775 COSE - 118	20715 208 E.D
			MJ100	145				
Resistive Load		Land					ni	Current Ca
Delay Time	W 250 W	- FO A I	167 4	t <sub>d</sub>		0.03	0.25	μS
Rise Time		$(V_{CC} = 250 \text{ Vdc}, I_C = 50 \text{ A}, I_{B1} = R_{BE} = 10 \Omega, t_p = 50 \mu s,$	1.67 A,	tr	-	0.9	3.0	abA 08 = n
Storage Time				ts		10	25	
Fall Time	Duty Cycle ≤ 2.0%)			tf	-	3.0	10	eotor-Emil
Inductive Load, C	Clamped					-	io = 6.0 Ado	p = 75 Add
	a c	ampou				Long to the same of	La serie de	
Storage Time	- (I <sub>CM</sub> = 50 A, V <sub>CEM</sub> = 250 V, R <sub>BE</sub> = 10 Ω,	TJ = 100°C	tsv		15	50	μS	
Crossover Time				t <sub>c</sub>		4.0	V no15	a-Emiriar
Storage Time	IB1 = 1.67 A)		T.J = 25°C	t <sub>sv</sub>		10 (5)	25	ch4 08 = 5
Crossover Time	0.6.			t <sub>c</sub>	- (	2.7	A 7810- BI	ppA 02 = g
			MJ100	048				
Resistive Load		1	_					
Dalay Time		1		1 . 1		0.025	0.25	Current Ga
Delay Time	(V <sub>CC</sub> = 150 Vdc, I <sub>C</sub>	= 100 A, I <sub>B1</sub>	= 2.75 A,	t <sub>d</sub>		0.035	0.25	
Rise Time	- (V <sub>CC</sub> = 150 Vdc, I <sub>C</sub> - R <sub>BE</sub> = 10 Ω, t <sub>p</sub> = 50		= 2.75 A,	t <sub>r</sub>	_	1.2 (56)	4.0	
Rise Time Storage Time		μS,	= 2.75 A,	t <sub>r</sub>	= = =	1.2	4.0	bA 001 = g
Rise Time Storage Time Fall Time	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)	μS,	= 2.75 A,	t <sub>r</sub>		1.2 6.3 2.5	4.0 20 8.0	n 2001 = 0 ector-Emil c = 100 Ad
Rise Time Storage Time Fall Time	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)	μS,	= 2.75 A,	t <sub>r</sub>		1.2	4.0 20 8.0	0 = 100 Ad ector-Emil c = 100 Ad
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq 2.0\%$	μS,		t <sub>r</sub>		1.2 6.3 2.5	4.0 20 8.0	bA 001 = 0 (int3-tebs) bA 001 = 0 bA 001 = 0 ( terj μ <b>s</b> ) -e
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)	μs, mexisov	= 2.75 A,  T <sub>J</sub> = 100°C	t <sub>r</sub> t <sub>s</sub> t <sub>f</sub>		1.2 6.3 2.5 9.0 3.3	4.0 20 8.0 30	bA 001 = 0 inf - 1etos hA 001 = 0 bA 001 = 0 1er; μS - e pA 001 = 0
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time Storage Time	RBE = $10 \Omega$ , $t_p = 50$ Duty Cycle $\leq 2.0\%$ )	μs, mexisov	T <sub>J</sub> = 100°C	t <sub>r</sub> t <sub>s</sub> t <sub>f</sub>		9.0 3.3 6.5	30 12 20	bA 001 = 0 inA 001 = 0 bA 001 = 0 hA 001 = 0 hA 001 = 0 λ 001 = 0
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)	μs, mexisov		t <sub>r</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub>	- O	1.2 6.3 2.5 9.0 3.3	4.0 20 8.0 30	μS
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time Storage Time Crossover Time	RBE = $10 \Omega$ , $t_p = 50$ Duty Cycle $\leq 2.0\%$ )	μs, mexisov	T <sub>J</sub> = 100°C	t <sub>r</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub>	- O	9.0 3.3 6.5	30 12 20	bA 001 = 0 inA 001 = 0 bA 001 = 0 hA 001 = 0 hA 001 = 0 λ 001 = 0
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time Storage Time Crossover Time Crossover Time	$R_{BE} = 10 \Omega, t_p = 50$ $Duty Cycle \leq 2.0\%$ $Clamped$ $(I_{CM} = 100 A, V_{CEM} = 150 V, R_{BI}$ $I_{B1} = 2.75 A)$ $ARACTERISTICS$	μs, mexisov	T <sub>J</sub> = 100°C	tr tsv tc tsv tc	- O	9.0 3.3 6.5	30 12 20	bA 001 = 0 inf - 1etos hA 001 = 0 bA 001 = 0 1er; μS - e pA 001 = 0
Rise Time Storage Time Fall Time Inductive Load, (C Storage Time Crossover Time Storage Time Crossover Time C-E DIODE CH Power Dissipation	$R_{BE} = 10 \Omega, t_p = 50$ $Duty Cycle \leq 2.0\%$ $Clamped$ $(I_{CM} = 100 A, V_{CEM} = 150 V, R_{BI}$ $I_{B1} = 2.75 A)$ $IARACTERISTICS$ $(I_{B} = 0)$	μs, mexisov	T <sub>J</sub> = 100°C	tr ts ts tf	- O	9.0 3.3 6.5 2.3	30 30 12 20 8.0	hA 001 = g
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time C-E DIODE CF Power Dissipatior Single Cycle Surg	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (IB = 0)  e Current (60 Hz)	μs, mexisov	T <sub>J</sub> = 100°C	tr ts ts tf  tsv tc tsv tc  tsv tc	- O	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0	μs w Apk
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Crossover Time Cressover Time C-E DIODE CH Power Dissipation Single Cycle Surg Forward Voltage (	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (IB = 0)  e Current (60 Hz)	μs, mexisov	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C	tr ts ts tf	- O	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0 30 12 20 8.0	hA 001 = g
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time Cressover Time Cressover Time C-E DIODE CF Power Dissipation Single Cycle Surg Forward Voltage ( (IF = 25 Adc)	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (IB = 0)  e Current (60 Hz)	μs, mexisov	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C	tr ts ts tf  tsv tc tsv tc  tsv tc	- O	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0 12 20 8.0	μs ω
Rise Time Storage Time Fall Time Inductive Load, ( Storage Time Crossover Time Storage Time Crossover Time Crossover Time Crossover Time C-E DIODE CF Power Dissipation Single Cycle Surg Forward Voltage ( IF = 25 Adc) (IF = 50 Adc)	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (IB = 0)  e Current (60 Hz)	μs, mexisov	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C MJ10042 MJ10045	tr ts ts tf  tsv tc tsv tc  tsv tc	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0 12 20 8.0 125 250	μs μs A OOT
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time Crossover Time Crossover Time Crossover Time Cressover Time Cres	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C	tr ts ts tf  tsv tc tsv tc  tsv tc	- O	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0 12 20 8.0	μs ω
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time Crossover Time Cre DIODE CF Power Dissipatior Single Cycle Surg Forward Voltage ( (IF = 25 Adc) (IF = 100 Adc) Reverse Recovery	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C MJ10042 MJ10045 MJ10048	tr ts ts tf  tsv tc tsv tc  tsv tc	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	30 12 20 8.0 30 12 20 8.0 125 250	μs ω
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Crossover Time Crossover Time Crossover Time Cre DIODE CH Power Dissipatior Single Cycle Surg Forward Voltage ( IF = 25 Adc) (IF = 50 Adc) (IF = 100 Adc) Reverse Recovery (IF = 25 Adc)	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C MJ10042 MJ10045 MJ10048	t <sub>r</sub> t <sub>s</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> V <sub>F</sub>	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 1.5 2.0	W Apk
Rise Time Storage Time Fall Time Inductive Load, (I Storage Time Crossover Time Storage Time Crossover Time Crossover Time Crossover Time Crossover Time Crossover Time Crossover Time (IF = DIODE CF Fower Dissipation Single Cycle Surg Forward Voltage (IF = 50 Adc) (IF = 100 Adc) (IF = 100 Adc) (IF = 25 Adc) (IF = 50 Adc) (IF = 50 Adc) (IF = 50 Adc)	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C  T <sub>J</sub> = 25°C  MJ10042 MJ10045 MJ10048  MJ10042 MJ10042 MJ10045	t <sub>r</sub> t <sub>s</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> V <sub>F</sub>	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 2.0	W Apk
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Crossover Time Crossover Time Crossover Time Cre DIODE Ch Power Dissipation Single Cycle Surg Forward Voltage ( If= 25 Adc) (If= 50 Adc) (If= 100 Adc) Reverse Recovery (If= 25 Adc)	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C T <sub>J</sub> = 25°C MJ10042 MJ10045 MJ10048	t <sub>r</sub> t <sub>s</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> V <sub>F</sub>	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 1.5 2.0	W Apk
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time Crossover Time Crossover Time Crossover Time C-E DIODE CF Power Dissipatior Single Cycle Surg Forward Voltage ( If= 25 Adc) (If= 100 Adc) Reverse Recovery (If= 25 Adc) (If= 50 Adc) (If= 50 Adc) (If= 50 Adc) (If= 50 Adc) (If= 100 Adc) Forward Turn-On	RBE = 10 $\Omega$ , t <sub>p</sub> = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS (IB = 0)  e Current (60 Hz)	= 10 Ω,	T <sub>J</sub> = 100°C  T <sub>J</sub> = 25°C  MJ10042 MJ10045 MJ10048  MJ10042 MJ10045 MJ10048	t <sub>r</sub> t <sub>s</sub> t <sub>s</sub> t <sub>f</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> t <sub>sv</sub> t <sub>c</sub> V <sub>F</sub>	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 2.0	W Apk
Rise Time Storage Time Fall Time Inductive Load, (I Storage Time Crossover Time Storage Time Crossover Time (IF = DIODE CF Power Dissipation Single Cycle Surg Forward Voltage (IF = 50 Adc) (IF = 100 Adc) (IF = 100 Adc) (IF = 50 Adc) (IF = 50 Adc) (IF = 50 Adc) (IF = 100 Adc)	RBE = 10 $\Omega$ , $t_p$ = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (I(B = 0)  e Current (60 Hz)  Time ( $d_i/d_t$ = 25 A/ $\mu$ :	= 10 Ω,	T <sub>J</sub> = 100°C  T <sub>J</sub> = 25°C  MJ10042 MJ10045 MJ10048  MJ10042 MJ10045 MJ10048	tr ts ts tc tsv tc tsv tc VF	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 2.0	W Apk Vdc
Rise Time Storage Time Fall Time Inductive Load, C Storage Time Crossover Time Storage Time Crossover Time Crossover Time Crossover Time C-E DIODE CF Power Dissipatior Single Cycle Surg Forward Voltage ( If= 25 Adc) (If= 100 Adc) Reverse Recovery (If= 25 Adc) (If= 50 Adc) (If= 50 Adc) (If= 100 Adc) Forward Turn-On	RBE = 10 $\Omega$ , $t_p$ = 50 Duty Cycle $\leq$ 2.0%)  Clamped  (ICM = 100 A, VCEM = 150 V, RBI IB1 = 2.75 A)  IARACTERISTICS  (I(B = 0)  e Current (60 Hz)  Time ( $d_i/d_t$ = 25 A/ $\mu$ :	= 10 Ω,	T <sub>J</sub> = 100°C  T <sub>J</sub> = 25°C  MJ10042 MJ10045 MJ10048  MJ10042 MJ10048	tr ts ts tc tsv tc tsv tc VF	() - - () - ()	1.2 6.3 2.5 9.0 3.3 6.5 2.3	4.0 20 8.0 30 12 20 8.0 125 250 1.5 2.0	W Apk Vdc

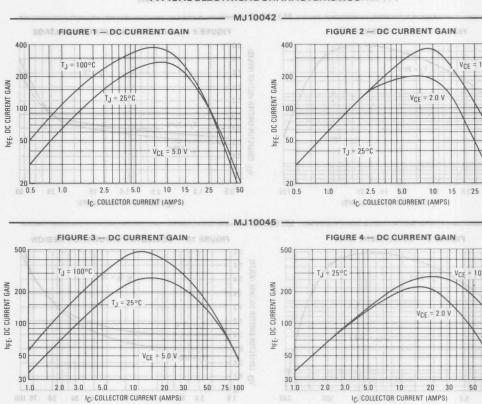
<sup>(1)</sup> Pulse Test: Pulse width of 300  $\mu$ s, duty cycle  $\leqslant$ 2.0%.

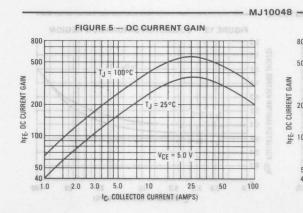
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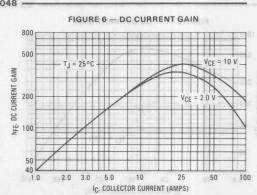
50

V<sub>CE</sub> = 10 V

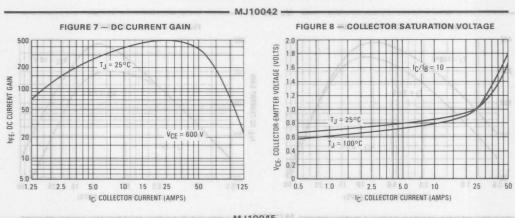
# TYPICAL ELECTRICAL CHARACTERISTICS



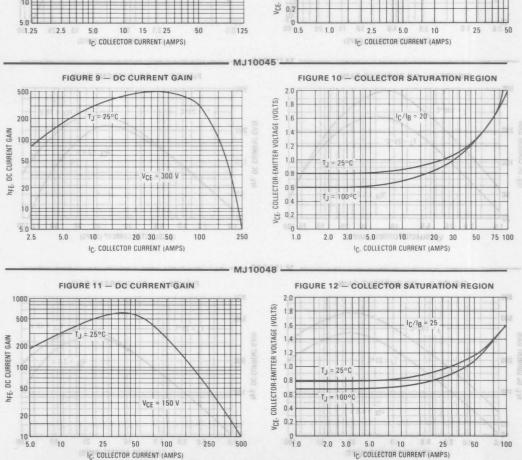




# TYPICAL ELECTRICAL CHARACTERISTICS (continued)

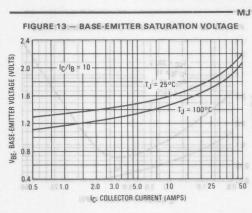


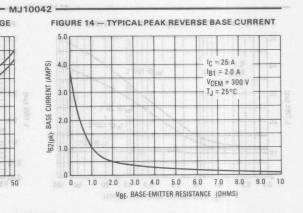


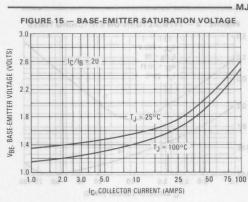


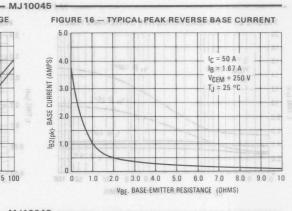
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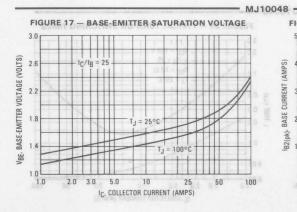
# TYPICAL ELECTRICAL CHARACTERISTICS (continued)

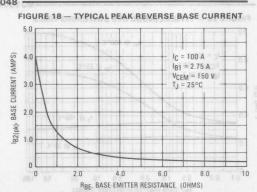




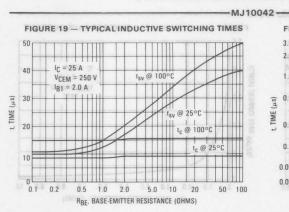


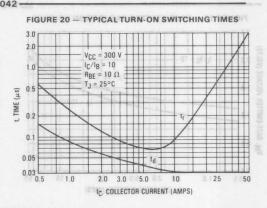


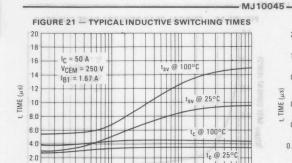




# TYPICAL ELECTRICAL CHARACTERISTICS (continued)



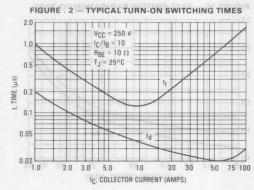


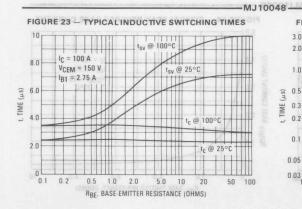


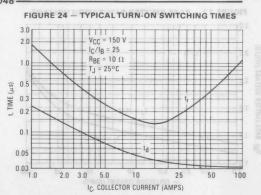
5.0

RBE. BASE-EMITTER RESISTANCE (DHMS)

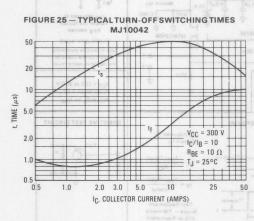
0.5 1.0 2.0

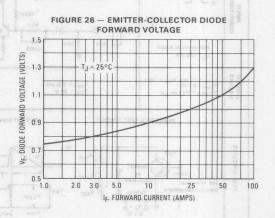


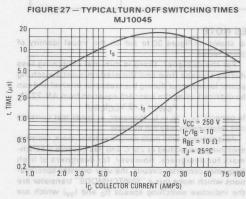


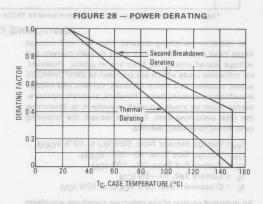


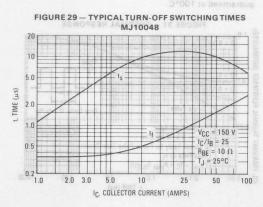
# TYPICAL ELECTRICAL CHARACTERISTICS (continued)

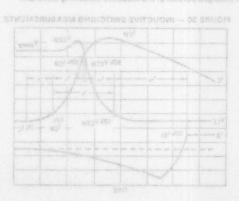


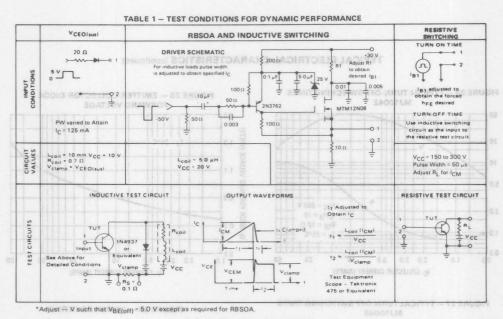












## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10 % VCEM

try = Voltage Rise Time, 10-90% VCEM

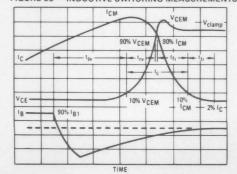
tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform

FIGURE 30 - INDUCTIVE SWITCHING MEASUREMENTS

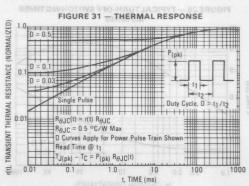


is shown in Figure 30 to aid on the visual identity of these terms.

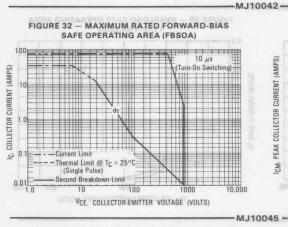
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A: PSWT = 1/2 VCCIC(tc)f

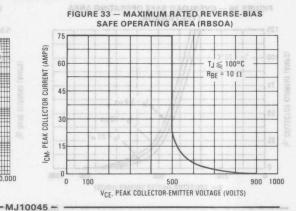
In general,  $t_{rv}$  +  $t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid.

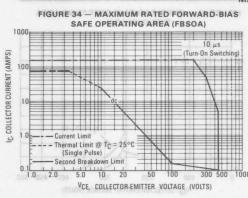
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

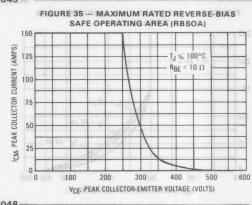


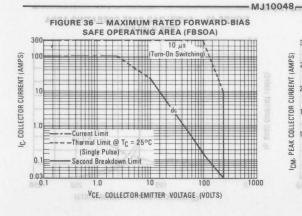
# SAFE OPERATING AREA INFORMATION

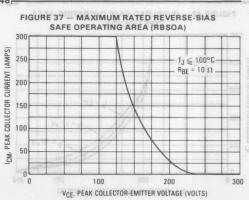




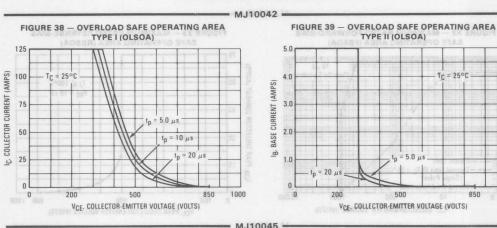


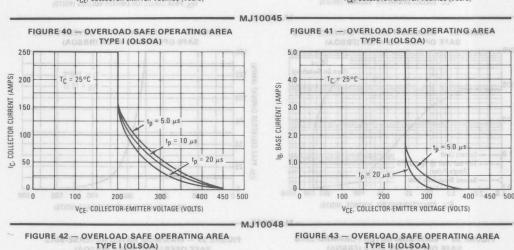


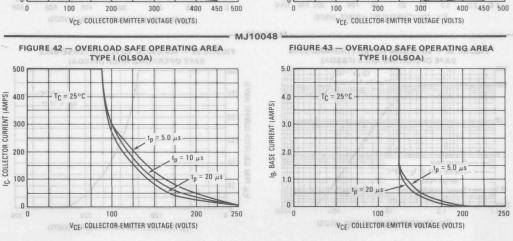




# OVERLOAD CHARACTERISTICS







# SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 32, 34 and 36 are based on  $T_C = 25^{\circ}\text{C}$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on these figures may be found at any case temperature by using the appropriate curve on Figure 28.

 $T_{J(pk)}$  may be calculated from the data in Figure 31. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figures 33, 35 and 37 give the RBSOA characteristics.

# **OVERLOAD SAFE OPERATING AREA**

The forward-bias safe operating area (FBSOA) specification given in these figures adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

# TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figures 38, 40 and 42 depict the Type I OLSOA rating for these devices. Maximum allowable collector-

emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, these figures define the maximum time which can be allowed for fault detection and shutdown of base drive.

MJ10042, MJ10045, MJ10048

Type I OLSOA is measured in a common-base circuit (Figure 44) which allows precise definition of collectoremitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

### TYPE II OLSOA

Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collectoremitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as shown in Figures 39, 41 and 43 are measured in the circuit shown in Figure 45, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NON-REPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for these devices is 100 occurrences. Another factor is the form of turn-off bias. For these devices, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from  $l_{\rm B2} = 0$  (soft) to  $l_{\rm BE(off)} = 5$  V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.

# OVERLOAD SAFE OPERATING TEST CIRCUITS

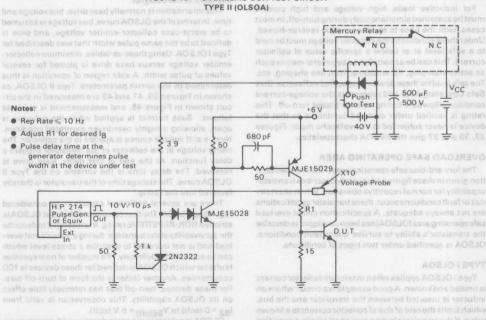
# There are two limitations on the powTIUDRID TEST ACC DADJAYO — 44 FIGURI IF glass width is defined as the time of a transistor everage junction temperature and suc. (ACCIO) I 19YT ween the fault condition and the removal of base been factored breakfown. Sele operating area universities IC—VCC with a state that the transistor that must be observed to reliable the curve. Stratege the curves indicate the factored breakform, i.e., the transistor must not be suffered with the curve that the maximum that the curves indicate the maximum that the curves indicate the curves indicated by Table 19 Tab

Notes:

- VCE = VCC + VBE
- Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>

high case comperatures, thermal limitations will reduce as not limited by pircuit of power that can be hendled to values loss than the gain of the transistor. The appear on the Type II OI appear on the Type II OI.

# FIGURE 45 — OVERLOAD SOA TEST CIRCUIT

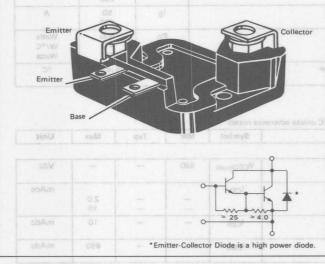




# Designer's Data Sheet

# **50 KVA SWITCHMODE TRANSISTOR 50-Ampere Operating Current**

The MJ10050 Darlington transistor is designed for industrial service under practical operating environments found in switching high power inductive loads off 460-Volt lines.



# **MAXIMUM RATINGS**

Mechanical Ratings		bessill-brew
Rating   sugar sea	Value	Unit
Mounting Torque (To heat sink with 10-32 Screw) (Note 1)	A0-20	inlb
Lead Torque (Lead to bus with 1/4-20 Screw) (Note 2)	20	inlb
Per Unit Weight	120	grams

# THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case, $R_{ heta$ JC	0.25	°C/W
Mica Insulators available as separate items		

0.003" thick. Motorola Part Number 14ASB12387B001. 0.006" thick. Motorola Part Number 14ASB12387B002.

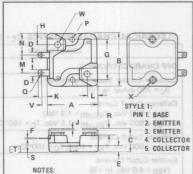
- 1. A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is
- 2. The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the terminal in the package. The torque may be increased to 50 in.-lb if support is used to prevent rotation. The maximum penetration of the screw should be limited to 0.75".

# 50 AMPERER lashtrell NPN SILICON POWER DARLINGTON TRANSISTOR

850 VOLTS 500 WATTS

### Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit datarepresenting device characteristics boundaries—are given to facilitate 'worst-case" design.



- 1. DIMENSION A AND B ARE DATUMS. T- IS SEATING PLANE.
- POSITIONAL TOLERANCE FOR
- MOUNTING HOLES ♦ 0.36 (0.014) M T AM BM

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	53.09	53.84	2.090	2.120
В	55.37	56.39	2.180	2.220
C	(5)(5)	26.67	- T -	1.050
D	6.10	6.60	0.240	0.260
E	6.60	7.11	0.260	0.280
F	0.71	0.81	0.028	0.032
G	43.3	1 BSC	1.70	5 BSC
Н	12.57	12.82	0.495	0.505
J	1.52	1.62	0.060	0.064
K	9.50	9.75	0.374	0.384
L	10.21	10.46	0.402	0.412
M	18.92	19.18	0.745	0.755
N	23.67	23.93	0.932	0.942
P	5.08	5.21	0.200	0.205
0	3.53	3.78	0.139	0.149
R	6.76	7.26	0.266	0.286
S	14.73	15.24	0.580	0.600
٧	5.33	5.84	0.210	0.230
W	6.40	6.65	0.252	0.262
X	7.37	7.87	0.290	0.310

CASE 346-01 100 500 6109 (1)

MAXIMUM RATINGS (Continued)

Electrical Ratings A 0				
MODILIE MAIN Rating		Symbol	Value	Unit
Collector-Emitter Voltage	TRANSISTOR	VCEO	850	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	ng Current	VCER	900	Vdc
Collector-Base Voltage	Interpretation and Interpretation	VCB	900	Vdc
Emitter-Base Voltage	ry designed for menantial	VEB	8.0	Vdc
Collector Current — Operating, T <sub>C</sub> = 125°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C	lings.	lov Oc no	50 75 150 250	nigiAcower
Base Current — Continuous — Peak Nonrepetitive		IB	50 100	А
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C  For 1-minute overload	rotuel 30	PD	500 4.0 667	Watts W/°C Watts
Operating Junction and Storage Temperature Range For 1-minute overload		TJ, T <sub>stg</sub>	-55 to +150 -55 to 200	°C

ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted)

Second Breakdown Collector Current with Base Forward-Biased

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 0)		VCEO(sus)	850	_	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 900 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 900 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	*	ICEV	-	=	2.0	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 900 Vdc, R <sub>BE</sub> = 10 Ω, T <sub>C</sub> = 100°C)	0 0	ICER	-0 -	-	10	mAdc
Emitter Cutoff Current (VEB = 4.0 Vdc, IC = 0)	h power diode.	IEBO III	tter-Cellector	ma' —	650	mAdc

FBSOA

See Figure 13

# SAFE OPERATING AREA

	RBSOA	See Figure 14			
di-,en	OLSOA	See	Figures 16 ar	d 17	nating Farque (1
20.00	nic -			Albert mark of	has II mass Th
	hFE				Vote 2)
grams	120	35 40			Unit Walght
	VCE(sat)		STICS	RACTER	Vdc
W/OF	0.25				
				2.5	ve anaisiusni s
	VBE(sat)	12367800		3.0	Vdc
			_	3.0	189
Oppounds that is	of bas loins. 4	200,010	72-0-0-020	a.O to recize	A Belleville w
erfolio collistos I				4000	ppo pF <sub>sled</sub> T
	Trotation of the	VBE(sat)	OLSOA See    hFE   35   40     VCE(sat)	OLSOA See Figures 16 and 16 an	OLSOA See Figures 16 and 17  hFE 35 — — — — — — — — — — — — — — — — — —

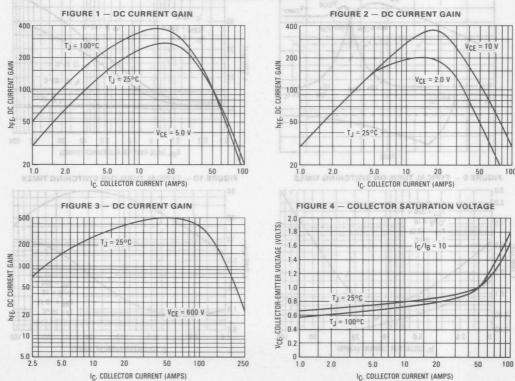
(1) Pulse Test. Pulse width of 300  $\mu$ s, duty cycle  $\leq$  2.0%.

ELECTRICAL CHARACTERISTICS (Continued) (T<sub>C</sub> = 25°C unless otherwise noted)

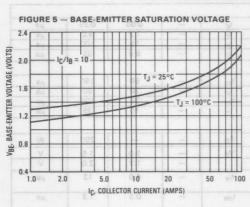
Characteristic			Symbol	Min	Тур	Max	Unit
SWITCHING CHA	ARACTERISTICS	ARACTERIST	TRICAL CH	CAL ELEC	TYPH		
Resistive Load	URE 6 - EMITTER-COLLECTO	ois					
Delay Time	FORWARD VOLTAGE		td	A NORME	0.03	0.25	μS
Rise Time $(VCC = 300 \text{ Vdc}, I_C = 50 \text{ A}, I_{B1} = R_{BE} = 10 \Omega, t_p = 50 \mu s,$		= 4.0 A,	tr	- 1	1.2	5.0	μS
			ts	-	35	100	μS
Fall Time	Duty Cycle ≤ 2.0%)		tf	-	8.5	35	μS
Inductive Load, C	Clamped	1 1 5	INN				
Storage Time	(I <sub>CM</sub> = 50 A, V <sub>CEM</sub> = 300 V, R <sub>BE</sub> = 10 Ω, I <sub>B1</sub> = 4.0 A)	T <sub>J</sub> = 100°C	tsv	- July 1	50	150	μS
Crossover Time			t <sub>C</sub>	-	20	60	μS
Storage Time		T <sub>J</sub> = 25°C	t <sub>sv</sub>	01 = 11 = 10	35	100	μS
Crossover Time			t <sub>c</sub>	-	10	35	μS
C-E DIODE CH	ARACTERISTICS	3					
Power Dissipation (I <sub>B</sub> = 0)		1	PD	- 1	411	250	W
Forward Voltage (1) (I <sub>F</sub> = 50 A) (I <sub>F</sub> = 100 A)		1 4 4	VF	- 1	1.0	1.5	V
				-	1.2	2.0	V
Reverse Recovery Time $(d_i/d_t = 25 \text{ A}/\mu\text{s. I}_F = 50 \text{ A})$			-651 <sup>t</sup> rr -68	- 05	4.0	12	μs
Forward Turn-On Time (Compliance Voltage = 50 V, I <sub>F</sub> = 50 A)			ton	-	0.3	1.2	μs
Single Cycle Surge Current (60 Hz)			IFSM	TYPICAL	_	500	Α

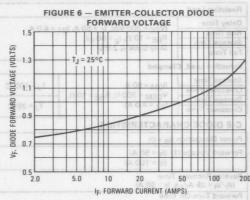
(1) Pulse Test. Pulse width of 300 µs, duty cycle ≤2.0%.

# TYPICAL ELECTRICAL CHARACTERISTICS









# TYPICAL SWITCHING CHARACTERISTICS

FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS

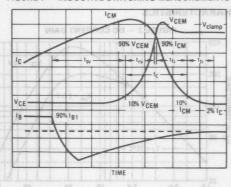


FIGURE 8 — TYPICAL INDUCTIVE SWITCHING TIMES

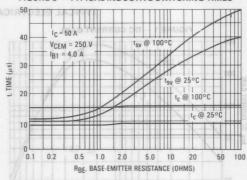


FIGURE 9 - TYPICAL TURN-ON SWITCHING TIMES

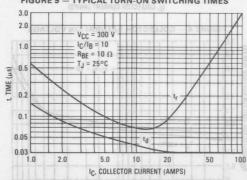


FIGURE 10 - TYPICAL TURN-OFF SWITCHING TIMES

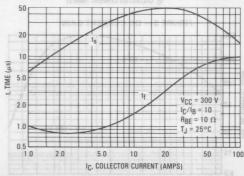


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE RESISTIVE VCEO(sus **RBSOA AND INDUCTIVE SWITCHING** TURN ON TIME +30 V DRIVER SCHEMATIC 200 Ω Adjust R1 CONDITIONS desired IB1 B1 adjusted to 10μF 50Ω obtain the forced h<sub>FE</sub> desired -11-2N3762 ₩ MTM1224 TURN-OFF TIME dh ₹ 500 Use inductive switching circuit as the input to 0.003 0 1 Ic = 100 mA the resistive test circui CIRCUIT L<sub>coil</sub> = 10 mH V<sub>CC</sub> = 10 V R<sub>coil</sub> = 0.7 Ω V<sub>CC</sub> = 300 V R<sub>L</sub> = 6.0 Ω L<sub>coil</sub> = 5.0 μH V<sub>CC</sub> = 20 V Vclamp " VCEO(sus) th = 25 μs INDUCTIVE TEST CIRCUIT RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to Obtain IC TUT ₹ VCC Lcoil (ICM) Vcc 1N4937 -0 Lcoil (ICM TEST See Above for V<sub>clamp</sub> Vclamp VCE VCEM Test Equipment = 0 R<sub>S</sub> = 0 Scope — Tektronix 475 or Equivalent \*Adjust - V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).

# **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10 % V<sub>CEM</sub>

t<sub>rv</sub> = Voltage Rise Time, 10—90% V<sub>CEM</sub>

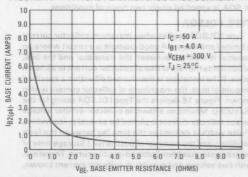
tfi = Current Fall Time, 90—10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform

FIGURE 11 — TYPICAL PEAK REVERSE BASE CURRENT

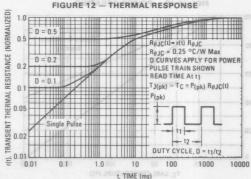


is shown in Figure 7 to aid on the visual identity of

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCCIC(tc)f In general,  $t_{rv} + t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

FIGURE 13 — MAXIMUM FORWARD-BIAS SAFE OPERATING AREA (FBSOA)

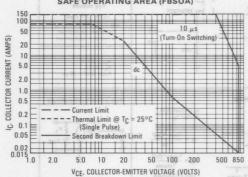


FIGURE 14 — MAXIMUM REVERSE-BIAS SAFE OPERATING AREA (RBSOA)

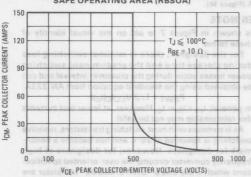
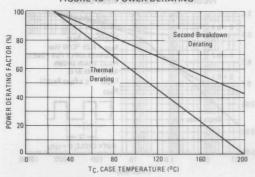


FIGURE 15 - POWER DERATING



# SAFE OPERATING AREA INFORMATION

# **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

T<sub>J(pk)</sub> may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

# OVERLOAD SAFE OPERATING AREA

The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions.

OLSOA is specified under two types of conditions.

## TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the MJ10050. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known,

(continued on back page)

# OVERLOAD CHARACTERISTICS

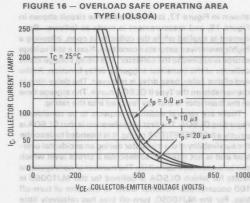


FIGURE 18 — OVERLOAD SOA TEST CIRCUIT TYPE I

# Notes: VCE = VCC + VBE Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>

FIGURE 17 — OVERLOAD SAFE OPERATING AREA

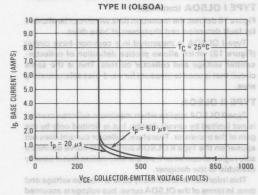
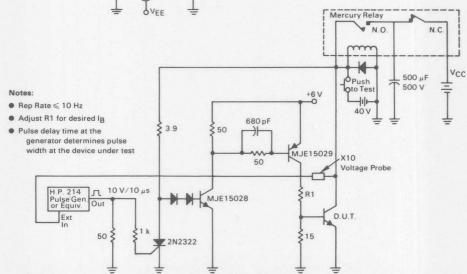


FIGURE 19 — OVERLOAD SOA TEST CIRCUIT TYPE II



3

## SAFE OPERATING AREA INFORMATION (continued)

## TYPE I OLSOA (continued)

Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

## TYPE II OLSOA

Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

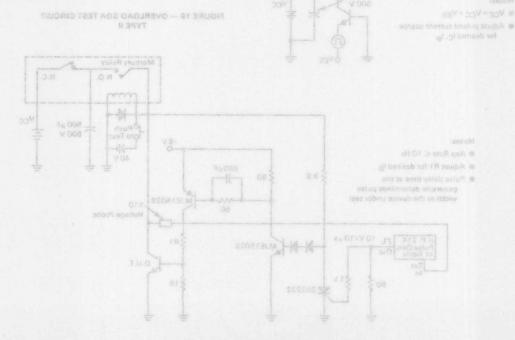
This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collectoremitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as

shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

HOURE 18 - OVERLOAD SAFE OPERATING AREA

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the MJ10050 is 100 occurrences. Another factor is the form of turn-off bias. For the MJ10050, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from IB2 = 0 (soft) to VBE(off) = 5 V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.



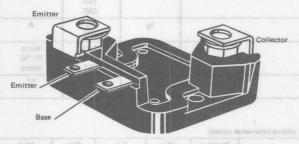
3

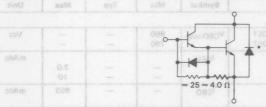


## Designer's Data Sheet

## 50 KVA HIGH SPEED SWITCHMODE TRANSISTOR 50-Ampere Operating Current

The MJ10051 Darlington transistor is designed for industrial service under practical operating environments requiring fast switching speed for highly efficient systems operating at high frequency such as inverters, PWM controllers and other high frequency system operating from 460 V lines.





\*Emitter-Collector Diode is a fast recovery, high power diode.

## **MAXIMUM RATINGS**

MECHANICAL RATINGS		
Rating	Value	Unit
Mounting Torque (To heat sink with 10-32 Screw) (Note 1)	20	inlb
Lead Torque (Lead to bus with 1/4-20 Screw) (Note 2)	20	inlb
Per Unit Weight	120	grams

## THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case,R<sub>Ø</sub>JC 0.25 °C/W Mica Insulators available as separate items.

0.003" thick. Motorola Part Number B12387B001.
0.006" thick. Motorola Part Number B12387B002.

### Notes

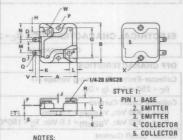
- A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is recommended such as P/N AM125206 available from National Disc Spring Div., 385 Hillside Ave., Hillside N.J. 07205.
- The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the terminal
  in the package. The torque may be increased to 50 in.-lb if support is used to prevent
  rotation. The maximum penetration of the screw should be limited to 0.75°.

# 50 AMPERE NPN SILICON POWER DARLINGTON TRANSISTOR

750 and 850 VOLTS 500 WATTS

## Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.



- NOTES:
  - 1. DIMENSION A AND B ARE DATUMS.
- 2. T. IS SEATING PLANE.
- 4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	53.09	53.84	2.090	2.120
В	55.37	56.39	2.180	2.220
C	-	26.67	-	1.050
D	6.10	6.60	0.240	0.260
E	6.60	7.11	0.260	0.280
F	0.71	0.81	0.028	0.032
G	43.3	BSC	1.709	BSC
Н	12.57	12.82	0.495	0.505
J	1.52	1.62	0.060	0.064
K	9.50	9.75	0.374	0.384
L	10.21	10.46	0.402	0.412
M	18.92	19.18	0.745	0.755
N	23.67	23.93	0.932	0.942
P	5.08	5.21	0.200	0.205
0	3.53	3.78	0.139	0.149
R	6.76	7.26	0.266	0.288
S	14.73	15.24	0.580	0.600
٧	5.33	5.84	0.210	0.230
W	6.40	6.65	0.252	0.262
X	7.37	7.87	0.290	0.310

MU10052

MAXIMUM RATINGS (Continued)		THE STATE	Server Cold	Mary Trans
ELECTRICAL RATINGS				
MOOLING MAN Rating	DE TRANSISTOR	Symbol	Value	Unit
Collector-Emitter Voltage	MJ10051 MJ10052	VCEO	850 750	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	designed for industrial	VCER	900	Vdc
Collector-Base Voltage	real primupor athemno	V <sub>CB</sub>	900	Vdc
Emitter-Base Voltage	dgid te gaira rego amat dad sedto bas asalloss	VEB	8.0	Vdc
Collector Current — Operating, T <sub>C</sub> = 125°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C	aut	W V Otlemon)	50 75 150 250	freq Ancy sy
Base Current — Continuous — Peak Nonrepetitive		IB	50 100	A
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C For 1-minute overload		PD	500 4.0 667	Watts W/°C Watts
Operating Junction and Storage Temperature Range For 1-minute overload		T <sub>J</sub> , T <sub>stg</sub>	-55 to +150 -55 to +200	°C

## ELECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 0)	MJ10051 MJ10052	VCEO(sus)	850 750	I	_	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 900 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 900 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)		ICEV	Ξ		2.0 10	mAdc
Emitter Cutoff Current (VEB = 4.0 Vdc, IC = 0)		IEBO	-	-	950	mAdc
SAFE OPERATING AREA	shalb revvo	recovery, high pa	rest s zi obo	Collector Dis	tortim3"	
Second Breakdown Collector Current with Base Fo	rward-Biased	FBSOA				

Second Breakdown Collector Current with Base Forward-Biased	FBSOA	and the second of the second o
Clamped Inductive SOA with Base Reverse-Biased	RBSOA	- BOWITAR MUMIX
Overload SOA	OLSOA	CHAMICAL RATINGS —

HaU	Value Uni		Pakafi			
dir.ni	hFE	25	with 10-32 Sa	gola med o	nting Torque ( ste 1)	
	20	40	/4-2 <del>0</del> Screw	driw <del>c</del> ud or	Yorque (Lead	
Author.	VCE(sat)			2.0	Vdc	
			80074	5.0	RMAL CHA	
97.01	V <sub>BF(sat)</sub>		5666.0303 c	2.5	Vdc	
	22(301)		a Xism <u>a.</u> er (1) 2 <u>1</u> 678001	3.0 3.0	insulatora everial 1981 thesi, Atoton	
	dini	h <sub>FE</sub>	VBE(sat)	PFE 25 — 40 — VCE(sat) — — — — — — VBE(sat)	VCE(sat) — — 2.0 — 2.5 VBE(sat) — — 3.0	

DYNAMIC CHARACTERISTICS						
Output Capacitance	Q nounds Hat is	Cob	1. D TU 0.20	0.05.0.00	4000	pF <sub>100</sub>
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	es Spring Div		meat siduling	* 905051MY	Booth se RVA	

<sup>(1)</sup> Pulse Test. Pulse width of 300  $\mu$ s, duty cycle  $\leq$ 2.0%.

2. The least receive models between to 20 in the unsupported to prevent rotation of the amplical in the package. The foreign are the process to 50 in to 3 diagnost is used to prevent in the package. The foreign and the increases to 50 in to 3 diagnost is used to prevent to 0.75° relative. The maximum penetration of the develope thought by instruct to 0.75°.

## ELECTRICAL CHARACTERISTICS (Continued) (T<sub>C</sub> = 25°C unless otherwise noted)

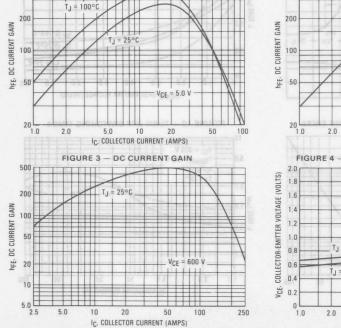
Characteristic		Symbol	Min	Тур	Max	Unit	
SWITCHING CH	ARACTERISTICS	THE PERSON A	ICAL CHAI	ELECTR	TYPICAL		
Resistive Load							
Delay Time	AV SECOND	The second secon	td 30A3	TON MOST	0.03	0.25	μS
Rise Time	(V <sub>CC</sub> = 300 Vdc, I <sub>C</sub> = 50 A, I <sub>B1</sub> = 5	5.U A,	tr		1.2	5.0	μS
Storage Time	$V_{BE(off)} = 5.0 \text{ V, t}_{p} = 50 \text{ μs,}$ Duty Cycle $\leq 2.0\%$ )		ts	-	3.3	10	μS
Fall Time	Duty Cycle \ 2.0%)	T_ 5.4 0	tf	-	1.5	5.0	μs
Inductive Load, C	Clamped	3	- IXX			1110	1701-1-10
Storage Time	(I <sub>CM</sub> = 50 A,	T 40000	tsv	70	5.0	15	μS
Crossover Time		T <sub>J</sub> = 100°C	tc	7-2	3.0	10	μS
Storage Time	VCEM = 300 V, VBE(off) = 5.0 V,	T <sub>1</sub> = 25°C	tsv		3.5	10	μS
Crossover Time	I <sub>B1</sub> = 5.0 A)	11-25-6	t <sub>C</sub>	-	1.5	5.0	μS
C-E DIODE CH	IARACTERISTICS	1 8	BOH H				The
Power Dissipation	n (I <sub>B</sub> = 0)	100	PD	-		250	W
Forward Voltage (	1) (I <sub>F</sub> = 50 A)	4 12	VF		2.7	5.0	V
Reverse Recovery		T lan	t <sub>rr</sub>		0.2	1.0	μs
$(di/dt = 50 A/\mu)$	s, I <sub>F</sub> = 50 A, V <sub>BE(off)</sub> = 5.0 V)	2.0	001 0	2 0	01	11.8	1.0 2.0
Forward Turn-On (Compliance Vo	Time   100 Mark   100 A   100		ton	18980	133 O.1 <sub>2 8012</sub>	1.0	μs
Single Cycle Surg	e Current (60 Hz)	TO SUBJECT	IFSM	10- 3-A 45-04	Long.	500	Α
Reverse Recovery	Current	TOPHNETO	IRM(REC)	No. of Street, or other	7.0	25	A
(IF = 50 A, di/dt	t = 50 A/μs)	2013	271(2)312	01100.000		SECTION AND ADDRESS OF	- TRRUPI

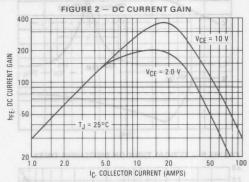
400

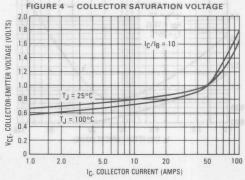
(1) Pulse Test. Pulse width  $\leqslant$  300  $\mu$ s, duty cycle  $\leqslant$ 2.0%. \*Requires negative base-emitter voltage for fast recovery performance.

FIGURE 1 - DC CURRENT GAIN

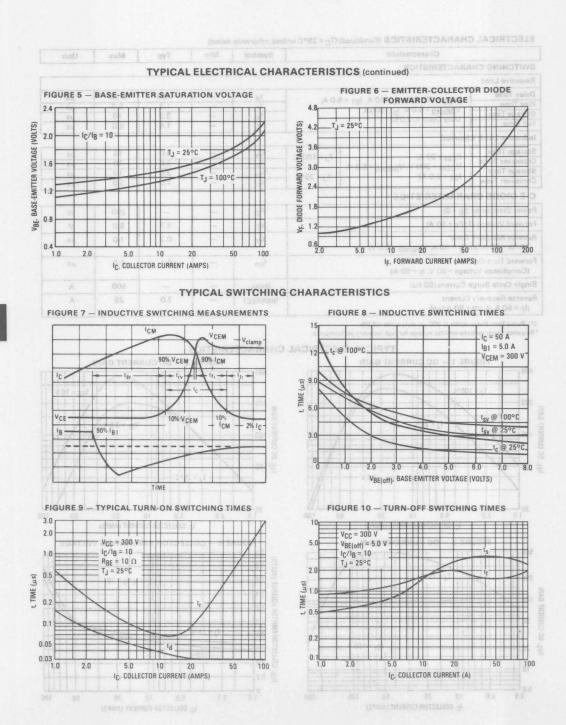
## TYPICAL ELECTRICAL CHARACTERISTICS











DESISTIVE VCEO(sus) DRSOA AND INDUCTIVE SWITCHING SWITCHING TURN ON TIME 20 Ω DRIVERSCHEMATIC 0.005 uf RR 10 CONDITIONS (2) 5.0 V [ T 0.005 2N3762 PG IB1 adjusted to T10 "F MTM14NOS HP214 IN obtain the forced \$10 -38 V TURN-OFF TIME PW Varied to Attain 0.05 µF Use inductive switching En S Ic = 250 mA ₹50 the resistive test circuit 1000 \$100 L<sub>coil</sub> = 10 mH V<sub>CC</sub> = 10 V L<sub>coil</sub> = 5.0 μH V<sub>CC</sub> = 20 V V<sub>CC</sub> = 300 V R<sub>L</sub> = 6.0 Ω Pulse Width = 25 μs R<sub>coil</sub> = 0.7 n CIRC V<sub>clamp</sub> = V<sub>CEO(sus)</sub> Drive OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT. t. Adjusted to Obtain Ic TUT t Clamped Vcc 0 Input V<sub>clamp</sub> TEST Fauryale Detailed Conditions V<sub>clamp</sub> Test Equipment VCEM Vclamp Scope - Tektronix 475 or Equivalent

TARLE 1 - BROOM AND INDUCTIVE SWITCHING DRIVER SCHEMATIC

\*Adjust - V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).

## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10 % VCEM

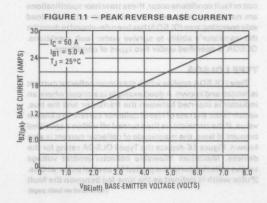
try = Voltage Rise Time, 10-90% VCEM

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform



is shown in Figure 7 to aid on the visual identity of these terms.

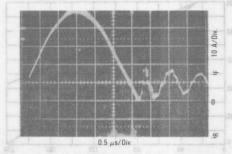
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCCIC(tc)f

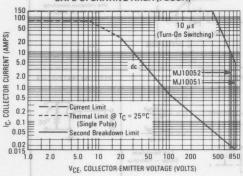
In general,  $t_{\Gamma V}$  +  $t_{fi} \simeq t_C.$  However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.

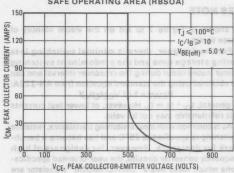
FIGURE 12 - REVERSE RECOVERY WAVEFORM



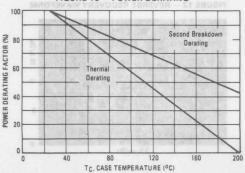
## FIGURE 13 — MAXIMUM FORWARD-BIAS SAFE OPERATING AREA (FBSOA)



## FIGURE 14 — MAXIMUM REVERSE-BIAS SAFE OPERATING AREA (RBSOA)



### FIGURE 15 - POWER DERATING



## SAFE OPERATING AREA INFORMATION

## **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

 $T_{J(pk)}$  may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

## OVERLOAD SAFE OPERATING AREA

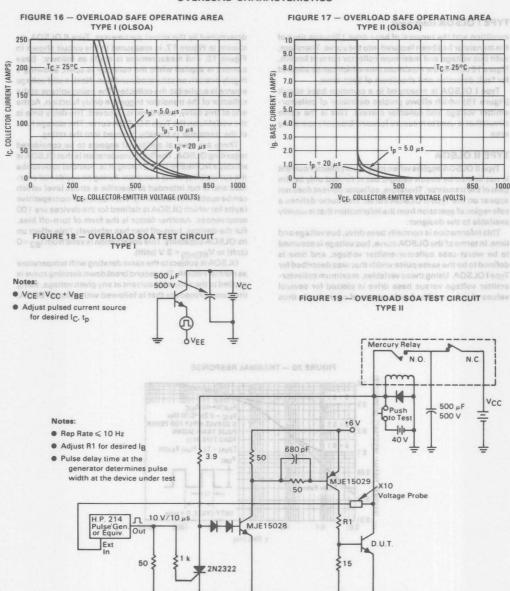
The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

### TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the devices. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault (continued on back page)

3

## OVERLOAD CHARACTERISTICS



## SAFE OPERATING AREA INFORMATION (continued)

## TYPE I OLSOA (continued)

condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known, Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

## TYPE II OLSOA

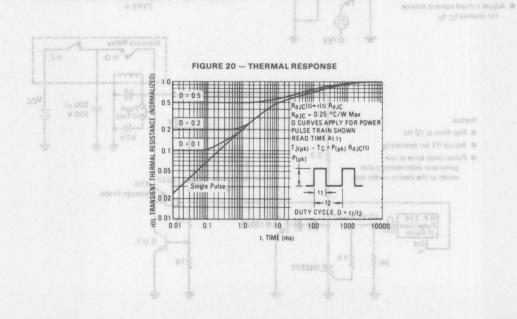
Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collector-emitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus

determined by the circuit parameters. Type II OLSOA, as shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the devices are 100 occurrences. Another factor is the form of turn-off bias. For the devices, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from IB2 = 0 (soft) to VBE(off) = 5 V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.

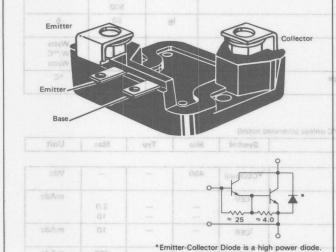




## Designer's Data Sheet

## 50 KVA SWITCHMODE TRANSISTOR 100-Ampere Operating Current

The MJ10100 Darlington transistor is designed for industrial service under practical operating environments found in switching high power inductive loads off 230-Volt lines.



## MAXIMUM RATINGS

Mechanical Ratings					
Rating	Value	Unit			
Mounting Torque (To heat sink with 10-32 Screw) (Note 1)	20 AG810	inlb			
Lead Torque (Lead to bus with 1/4-20 Screw) (Note 2)	20	inlb			
Per Unit Weight	120	grams			

## THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case, R<sub>B</sub>JC 0.25 °C/W

Mica Insulators available as separate items.

0.003" thick. Motorola Part Number 14ASB12387B001

0.006" thick. Motorola Part Number 14ASB12387B002.

### Notes

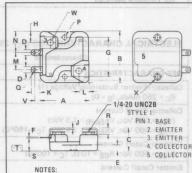
- A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is recommended.
- The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the
  terminal in the package. The torque may be increased to 50 in.-lb if support is used to
  prevent rotation. The maximum penetration of the screw should be limited to 0.75".

## 100 AMPERE NPN SILICON POWER DARLINGTON TRANSISTOR

450 VOLTS 500 WATTS

### Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data-representing device characteristics boundaries—are given to facilitate "worst-case" design.



## IOTES: 1. DIMENSION A AND B ARE DATUMS.

- 2. T- IS SEATING PLANE.
- 3. POSITIONAL TOLERANCE FOR

	MILLIN	ETERS	INC	HES
MIC	MIN	MAX	MIN	MAX
A	53.09	53.84	2.090	2.120
В	55.37	56.39	2.180	2.220
C	-	26.67	718	1.050
D	6.10	6.60	0.240	0.260
E	6.60	7.11	0.260	0.280
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H	12.57	12.82	0.495	0.505
J	1.52	1.62	0.060	0.064
K	9.50	9.75	0.374	0.384
L	10.21	10.46	0.402	0.412
M	18.92	19.18	0.745	0.755
N	23.67	23.93	0.932	0.942
P	5.08	5.21	0.200	0.205
0	3.53	3.78	0.139	0.149
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S	14.73	15.24	0.580	0.600
٧	5.33	5.84	0.210	0.230
W	6.40	6.65	0.252	0.262
X	7.37	7.87	0.290	0.310
	CA	SE 34	6-01	-
	- M	0-040	AA	

MAXIMUM RATINGS (Continued)	在2012年1月1日 1月1日 1月1日 1月1日 1月1日 1月1日 1月1日 1月1日	15.15.1 × 1							
Electrical Ratings									
MOTOMIJRAG REWORRING	E POTE LA	Symbol	Value	Unit					
Collector-Emitter Voltage	NUTURE	VCEO	450	Vdc					
Collector-Emitter Voltage (RBE = 10 Ohms)	21/01/	VCER	500	Vdc					
Collector-Base Voltage	Isintaubni tol bangia	ab a TO VCB	500	Vdc					
Emitter-Base Voltage	ta found in switching	nem le VEB	8.0	Vdc					
Collector Current — Operating, T <sub>C</sub> = 87.5°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C		lc	100 150 300 500	A					
Base Current — Continuous  — Peak Nonrepetitive	(8)	IB	50 100	A					
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C For 1-minute overload		PD	500 4.0 667	Watts W/°C Watts					
Operating Junction and Storage Temperature Range For 1-minute overload	ge	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150 -55 to +200	°C					

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	9				
Collector-Emitter Sustaining Voltage (1) (IC = 250 mAdc, IB = 0)	VCEO(sus)	450	-	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 500 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 500 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)	ICEV		=	2.0	mAdo
Collector Cutoff Current ( $V_{CE}$ = 500 Vdc, $R_{BE}$ = 10 $\Omega$ , $T_{C}$ = 100°C)	CER	-	_	10	mAdd
Emitter Cutoff Current (VEB = 4.0 Vdc, IC = 0)	IEBO	0138 <u>10</u> 3 100		650	mAdo

## SAFE OPERATING AREA

Clamped Inductive SOA with Base Reverse-Bias	ed	RBSOA		See Figure 1	4	
Overload SOA		OLSOA	10000	Figures 16 a	winie tabric	T) output Tentine (1)
ON CHARACTERISTICS (1)	disar	20		/4-20 Screw!	I (fliw and o	Torque (Lead
DC Current Gain (I <sub>C</sub> = 100 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 100 A, V <sub>CE</sub> = 10 V)	grants	hFE	50 60	=	_	ste 2) Jait Weight
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 100 Adc, I <sub>B</sub> = 3.3 A)	[ w/3° ]	V <sub>CE(sat)</sub>	_	DLAFLESS .	2.0	Vdc
I <sub>C</sub> = 150 Adc, I <sub>B</sub> = 12 A) (I <sub>C</sub> = 100 Adc, I <sub>B</sub> = 3.3 A, T <sub>C</sub> = 100°C)			00875861	arete Troms	3.3 2.5	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 100 Adc, I <sub>B</sub> = 3.3 Adc) (I <sub>C</sub> = 100 Adc, I <sub>B</sub> = 3.3 Adc, T <sub>C</sub> = 100°C)	ai 160 ahrman fi	VBE(sat)	208/865/	BAAT redox	3.0 3.0	Vdc 300

Second Breakdown Collector Current with Base Forward-Biased FBSOA See Figure 13

## DYNAMIC CHARACTERISTICS

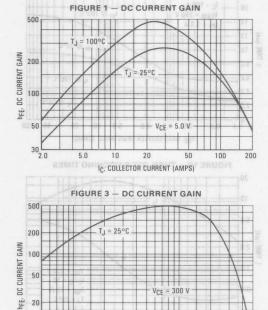
Output Capacitance	Cob	eddine Williams	HOS officialities	4000	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	nte trate. Ni Gill ol	besseroare)	hate epibling	AL BRINGH	off or burners

<sup>(1)</sup> Pulse Test. Pulse width of 300  $\mu\text{s},$  duty cycle  $\leqslant\!2.0\%.$ 

	Characteristic		Symbol	Min	Тур	Max	Unit
SWITCHING CH	ARACTERISTICS	BACTERISTI	RICAL CHA	AL ELECT	TYPIC		
Resistive Load	SEE A - RUTTER-COLLECTO	1049					
Delay Time	N/ - 250 V/- 1 - 300 A L	224	td	NA MOUN	0.03	0.25	μS
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 100 A, I <sub>B</sub>	11 = 3.3 A,	tr	THE TOTAL	0.9	3.0	μS
Storage Time	$R_{BE} = 10 \Omega, t_p = 50 \mu s,$		ts		10	25	μS
Fall Time	Duty Cycle ≤ 2.0%)		tf	1913	3.0	10	μS
Inductive Load, C	Clamped	1 3	N			Aliiri E	
Storage Time		T - 10000	tsv	1111	15	50	μS
Crossover Time	(I <sub>CM</sub> = 100 A,	T <sub>J</sub> = 100°C	t <sub>C</sub>	111	4.0	15	μS
Storage Time	V <sub>CEM</sub> = 250 V, R <sub>BE</sub> = 10 Ω,	T1 = 25°C	t <sub>sv</sub>	N. I	10	25	μS
Crossover Time	I <sub>B1</sub> = 3.3 A)	13 = 25 - 0	t <sub>C</sub>	NIT	2.7	10	μS
C-E DIODE CH	IARACTERISTICS	3			4		
Power Dissipation	(I <sub>B</sub> = 0)	77.0	PD	1111		250	W
Forward Voltage (	(1) (I <sub>F</sub> = 100 A)		VF	111-000	1.1	1.5	V
	(I <sub>F</sub> = 200 A)			111+11	1.4	2.0	V
Reverse Recovery (d <sub>i</sub> /d <sub>t</sub> = 25 A/µ	Time s, I <sub>F</sub> = 100 A)	2.0	oct <sub>rr</sub> ac	50- 1	3.3	8/ 10 92	μs ns
Forward Turn-On			ton	-	0.3	1.0	μS
Single Cycle Surg	e Current (60 Hz)	CHARACTER	IFSM	S JADINI	F	500	Α

(1) Pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse Width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse Width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse Width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse Test. Pulse Width of 300 μs, duty cycle ≤2.0%, https://doi.org/10.100/j.com/pulse W

## TYPICAL ELECTRICAL CHARACTERISTICS

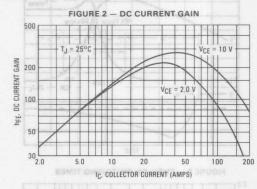


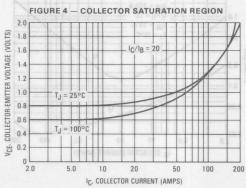
5.0

10

VCE = 300 V

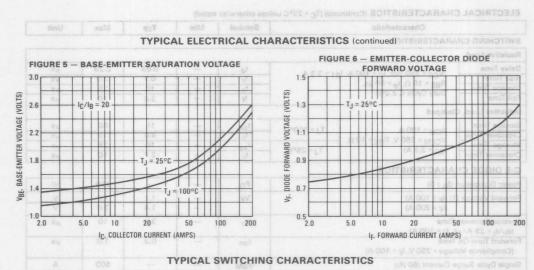
IC. COLLECTOR CURRENT (AMPS)

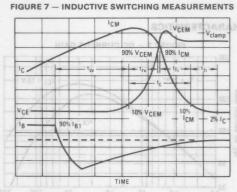


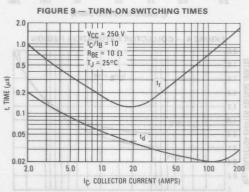


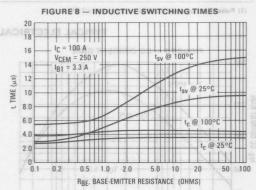
500

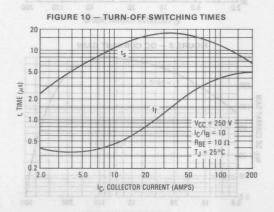


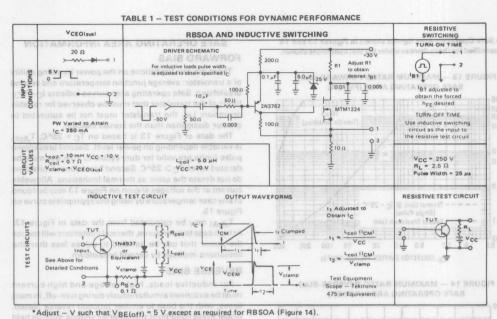












to suley alloage a woled to its SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10 % VCEM

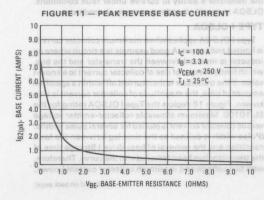
t<sub>rv</sub> = Voltage Rise Time, 10—90% V<sub>CEM</sub>

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform

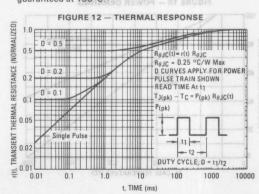


is shown in Figure 7 to aid on the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

 $PSWT = 1/2 \ V_{CC} | C(t_C) f$  In general,  $t_{rV} + t_{fi} \simeq t_C$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

FIGURE 13 — MAXIMUM RATED FORWARD BIAS, SAFE OPERATING AREA (FBSOA)

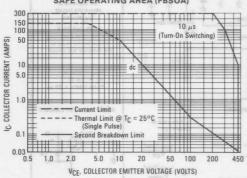


FIGURE 14 — MAXIMUM RATED REVERSE-BIAS SAFE OPERATING AREA (RBSOA)

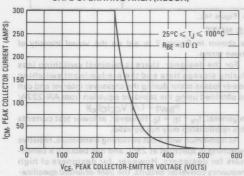
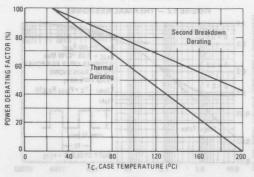


FIGURE 15 - POWER DERATING



## SAFE OPERATING AREA INFORMATION FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

 $T_{J(pk)}$  may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode, Figure 14 gives the RBSOA characteristics.

## **OVERLOAD SAFE OPERATING AREA**

The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

### TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the MJ10100. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known,

(continued on back page)

## OVERLOAD CHARACTERISTICS

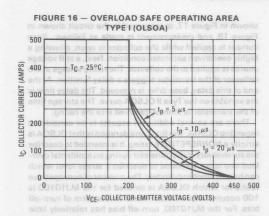
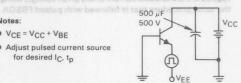


FIGURE 17 — OVERLOAD SAFE OPERATING AREA TYPE II (OLSOA) 10  $T_C = 25$ °C 8.0 BASE CURRENT (AMPS) 6.0 4.0 = 20 µs 200 300 400 450 500

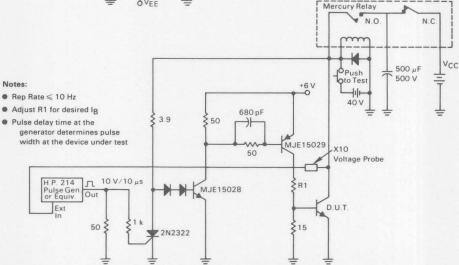
VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

FIGURE 18 — OVERLOAD SOA TEST CIRCUIT

- V<sub>CE</sub> = V<sub>CC</sub> + V<sub>BE</sub>
- Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>



## FIGURE 19 — OVERLOAD SOA TEST CIRCUIT TYPE II



## SAFE OPERATING AREA INFORMATION (continued)

## TYPE I OLSOA (continued)

Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

## TYPE II OLSOA

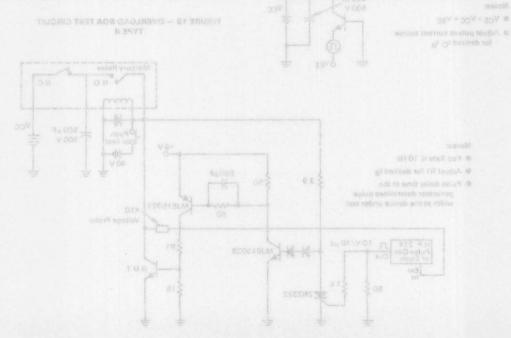
Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collector-emitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as

shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the MJ10100 is 100 occurrences. Another factor is the form of turn-off bias. For the MJ10100, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from  $l_{B2}$  = 0 (soft) to  $V_{BE(off)}$  = 5 V (stiff). OLSOA is subject to the same derating with temperature

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.



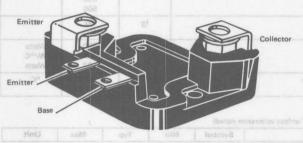
3

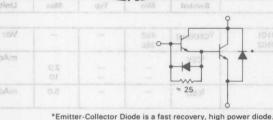


## Designer's Data Sheet

## 50 KVA HIGH SPEED SWITCHMODE TRANSISTOR 100-Ampere Operating Current

The MJ10101 Darlington transistor is designed for industrial service under practical operating environments requiring fast switching speed for highly efficient systems operating at high frequency such as inverters, PWM controllers and other high frequency systems operating from 230 V lines.





## **MAXIMUM RATINGS**

Mechanical Ratings		
Rating	Value	Unit
Mounting Torque (To heat sink with 10-32 Screw) (Note 1)	20 39 <sup>ti</sup>	inlb
Lead Torque (Lead to bus with 1/4-20 Screw) (Note 2)	20	inlb
Per Unit Weight	120	grams

## THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case, $R_{ heta JC}$	0.25	°C/W
Mica Insulators available as separate items.	Distribution	

0.003" thick. Motorola Part Number B12387B001. 0.006" thick. Motorola Part Number B12387B002.

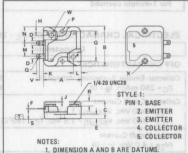
- 1. A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is recommended such as P/N AM125206 available from National Disc Spring Div., 385 Hillside Ave., Hillside N.J. 07205.
- 2. The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the terminal in the package. The torque may be increased to 50 in.-lb if support is used to prevent rotation. The maximum penetration of the screw should be limited to 0.75".

## 100 AMPERE **NPN SILICON** POWER DARLINGTON TRANSISTOR

350 and 450 VOLTS 500 WATTS

### Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit datarepresenting device characteristics boundaries—are given to facilitate "worst-case" design.



- 2. T- IS SEATING PLANE.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLES ♦ 0.36 (0.014)M T AM BM
- 4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIN	ETERS	INC	INCHES		
MID	MIN	MAX	MIN	MAX		
A	53.09	53.84	2.090	2.120		
В	55.37	56.39	2.180	2.220		
C	0 50	26.67	1 1-11	1.050		
D	6.10	6.60	0.240	0.260		
E	6.60	7.11	0.260	0.280		
F	0.71	0.81	0.028	0.032		
G	43.3	BSC	1.70	5 BSC		
Н	12.57	12.82	0.495	0.505		
J	1.52	1.62	0.060	0.064		
K	9.50	9.75	0.374	0.384		
L	10.21	10.46	0.402	0.412		
M	18.92	19.18	0.745	0.755		
N	23.67	23.93	0.932	0.942		
P	5.08	5.21	0.200	0.205		
0	3.53	3.78	0.139	0.149		
R	6.76	7.26	0.266	0.286		
S	14.73	15.24	0.580	0.600		
V	5.33	5.84	0.210	0.230		
W	6.40	6.65	0.252	0.262		
X	7.37	7.87	0.290	0.310		

CASE 346-01

5.0

mAdc

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Electrical Ratings						
Rating	Я	E TRANSISTO	a s	ymbol	Value	( A Unit)
Collector-Emitter Voltage	MJ10101 MJ10102	men	iC) grifts	VCEO	450 350	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	leinn	isigned for indus	9b 8i 102	VCER	500	Vdc
Collector-Base Voltage		goingperemen		VCB	500	Vdc
Emitter-Base Voltage	1	Here and other		VEB	8.0	Vdc
Collector Current — Operating, T <sub>C</sub> = 87.5°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C	°C	A	30 V Ilna	Icon	100 150 300 500	reque <b>A</b> cy sy
Base Current — Continuous  — Peak Nonrepetitive		<b>60</b>		1 <sub>B</sub>	50 100	Aima
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C For 1-minute overload				PD	500 4.0 667	Watts W/°C Watts
Operating Junction and Storage Temperature Ra For 1-minute overload	inge		Т	J, T <sub>stg</sub>	-55 to +150 -55 to +200	°C <sub>antima</sub>
ELECTRICAL CHARACTERISTICS (T <sub>C</sub> = 2	5°C unless othe	erwise noted)				× 96.08
Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS		9				
	MJ10101 MJ10102	VCEO(sus)	450 350	-		Vdc
Collector Cutoff Current (VCE = 500 Vdc, VBE(off) = 1.5 Vdc) (VCE = 500 Vdc, VBE(off) = 1.5 Vdc, TC = 150°C		ICEV	_	_	2.0	mAdc

### SAFE OPERATING AREA See Figure 13 Second Breakdown Collector Current with Base Forward-Biased FBSOA Clamped Inductive SOA with Base Reverse-Biased RBSOA See Figure 14 Overload SOA OLSOA See Figures 16 and 17

IEBO

### ON CHARACTERISTICS (1) DC Current Gain hFE (I<sub>C</sub> = 100 Adc, V<sub>CE</sub> = 5.0 Vdc) (I<sub>C</sub> = 100 A, V<sub>CE</sub> = 10 V) 50 60 Collector-Emitter Saturation Voltage VCE(sat) Vdc (IC = 100 Adc, IB = 3.3 A) 2.0 I<sub>C</sub> = 150 Adc, I<sub>B</sub> = 12 A) (I<sub>C</sub> = 100 Adc, I<sub>B</sub> = 3.3 A, T<sub>C</sub> = 100°C) 3.3 2.5 Base-Emitter Saturation Voltage Vdc VBE(sat) (IC = 100 Adc, IB = 3.3 Adc) 3.0 (I<sub>C</sub> = 100 Adc, I<sub>B</sub> = 3.3 Adc, T<sub>C</sub> = 100°C) 3.0

### DYNAMIC CHARACTERISTICS Output Capacitance Cob 4000 (VCB = 10 Vdc, IE = 0, ftest = 1.0 kHz)

**Emitter Cutoff Current** 

(V<sub>EB</sub> = 4.0 Vdc, I<sub>C</sub> = 0)

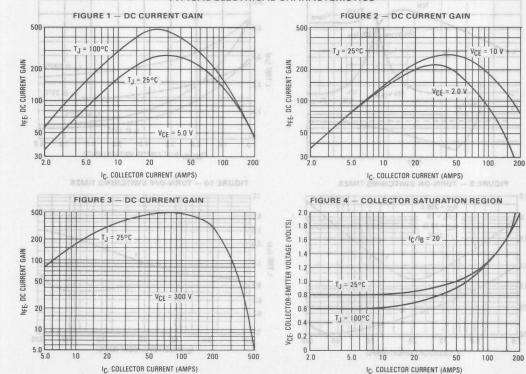
<sup>(1)</sup> Pulse Test. Pulse width of 300  $\mu$ s, duty cycle  $\leq$  2.0%.

ELECTRICAL CHARACTERISTICS (Continued) (T<sub>C</sub> = 25°C unless otherwise noted)

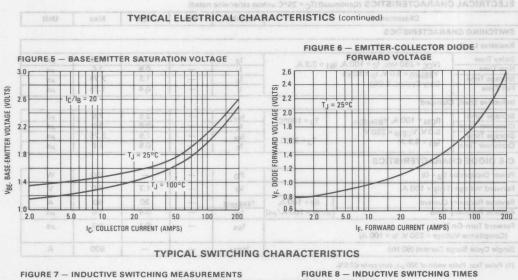
	Characteristic	NACTERISTICS	Symbol	Min	Тур	Max	Unit
SWITCHING CH	ARACTERISTICS						
Resistive Load	8 - EMITTER-COLLECTOR	PIGURE					
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 100 A, I	P1 = 3.3 A.	t <sub>d</sub> 30	ATJOY 9/01	0.03	0.25	μs
Rise Time	V <sub>BE(off)</sub> = 5.0 V, t <sub>p</sub> = 50 μs	2.6	tr	THE	0.9	3.0	μS
Storage Time	Duty Cycle ≤ 2.0%)	26	ts		1.5	3.75	μS
Fall Time	50.7 570.0 < 2.0707		tf		0.4	1.25	μS
Inductive Load, C	Clamped	- F - F - F - F - F - F - F - F - F - F	N.			95 = 81	9 1
Storage Time	(ICM = 100 A, VBE(off) =	T <sub>.1</sub> = 100°C	tsv		2.5	7.5	μS
Crossover Time	and the state of t	13-100 6	tc		0.8	3.0	μS
Storage Time	5.0 V, V <sub>CEM</sub> = 250 V	T.1 = 25°C	tsv	40411	1.5	3.75	μS
Crossover Time	I <sub>B1</sub> = 3.3 A)	13-25-0	tc	NUT	0.5	1.5	μS
C-E DIODE CH	IARACTERISTICS			TIME.	- Just = 11		I
Power Dissipation	n (I <sub>B</sub> = 0)	1 1 10	PD		HET	250	W
Forward Voltage (	1) (I <sub>F</sub> = 100 A)		VF	111-278	1.7	5.0	V
Reverse Recovery	Current	(I <sub>F</sub> = 100 A,	IRM(rec)	111-111	20	50	A
Reverse Recovery	Time	di/dt = 100 A/μs)	t <sub>rr</sub>	not no	0.4	1.0	μS
Forward Turn-On (Compliance Vo	Time (Itage = 250 V, I <sub>F</sub> = 100 A)		ton	- (898	(A) TO 0.100 R	0.5	μs
Single Cycle Surg	e Current (60 Hz)	PHESTOADANA	IFSM	NO TACH	10.00	500	A

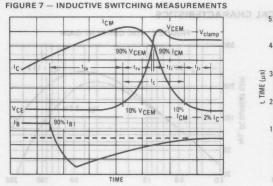
(1) Pulse Test. Pulse width of 300  $\mu$ s, duty cycle  $\leqslant$  2.0%.

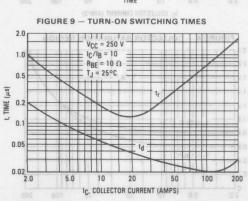
## TYPICAL ELECTRICAL CHARACTERISTICS

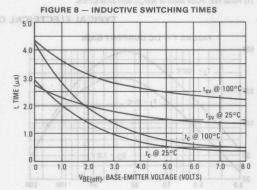


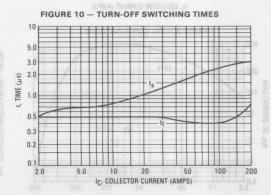


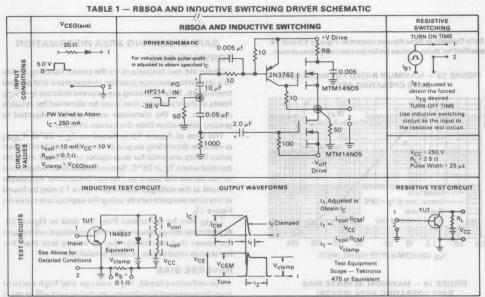












\*Adjust - V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).

## **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10 % V<sub>CEM</sub>

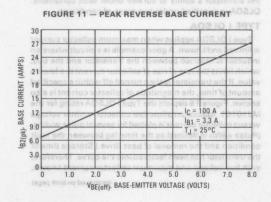
try = Voltage Rise Time, 10-90% VCEM

tfi = Current Fall Time, 90—10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform



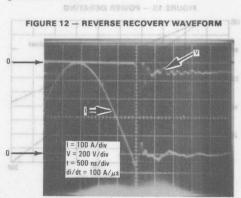
is shown in Figure 7 to aid on the visual identity of these terms

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCClc(t<sub>c</sub>)f

In general,  $t_{rv}$  +  $t_{fi}$  =  $t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

FIGURE 13 — MAXIMUM RATED FORWARD BIAS, SAFE OPERATING AREA

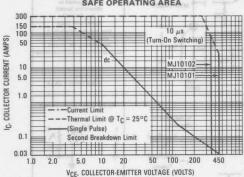


FIGURE 14 — MAXIMUM REVERSE-BIAS SAFE OPERATING AREA (RBSOA)

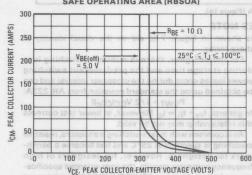
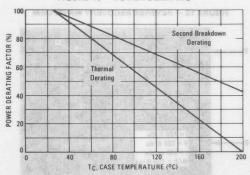


FIGURE 15 - POWER DERATING



## SAFE OPERATING AREA INFORMATION FORWARD BIAS

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25$ °C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

T<sub>J(pk)</sub> may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

## **OVERLOAD SAFE OPERATING AREA**

The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

## TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the MJ10101. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known.

(continued on back page)

OVERLOAD CHARACTERISTICS

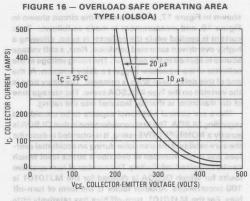


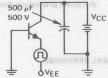
FIGURE 17 — OVERLOAD SAFE OPERATING AREA TYPE II (OLSOA) 101 TC = 25°C  $t_p = 10 \mu s$ CURRENT (AMPS) 5.0 BASE è 1.0 200 400 300 VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

FIGURE 18 — OVERLOAD SOA TEST CIRCUIT

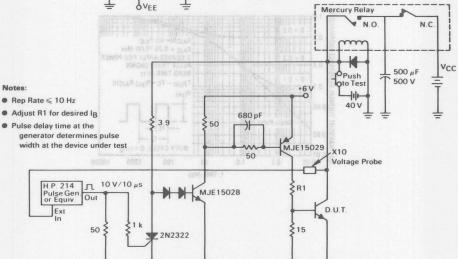
## TYPE I

### Notes:

- V<sub>CE</sub> = V<sub>CC</sub> + V<sub>BE</sub>
- Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>



## FIGURE 19 - OVERLOAD SOA TEST CIRCUIT



## SAFE OPERATING AREA INFORMATION (continued)

## TYPE I OLSOA (continued)

Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

## TYPE II OLSOA

Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collectoremitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as

FIGURE 18 - OVERLOAD SOA TEST CIRCUIT

shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the MJ10101 is 100 occurrences. Another factor is the form of turn-off bias. For the MJ10101, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from I<sub>R2</sub> = 0 (soft) to V<sub>RE(off)</sub> = 5 V (stiff).

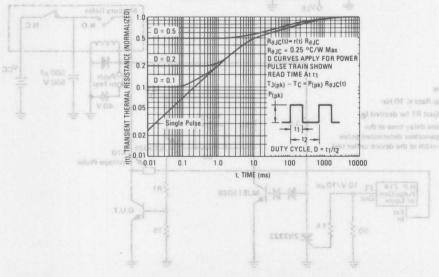
from I<sub>B2</sub> = 0 (soft) to V<sub>BE(off)</sub> = 5 V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.

@ VCE = VCC + VBE

for desired lc. to



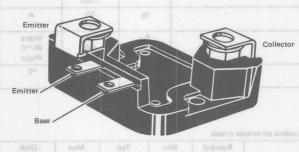


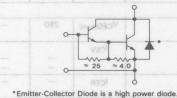


## Designer's Data Sheet

## **50 KVA SWITCHMODE TRANSISTOR** 200-Ampere Operating Current

The MJ10200 Darlington transistor is designed for industrial service under practical operating environments found in switching high power inductive loads off 120-Volt lines.





## **MAXIMUM RATINGS**

Mechanical Ratings		
Rating 1 sup 3 esc	Value	be Unit DISM
Mounting Torque (To heat sink with 10-32 Screw)	A 20	inlb
(Note 1) TI bas 31 serupi3 ee2	OLSOA	
Lead Torque (Lead to bus with 1/4-20 Screw) (Note 2)	20	inlb
Per Unit Weight	120	grams

## THERMAL CHARACTERISTICS

ı	Thermal Resistance, Junction	to case, ngJC	0.25	-C/VV
1				

Mica Insulators available as separate items.

0.003" thick. Motorola Part Number 14ASB12387B001. 0.006" thick. Motorola Part Number 14ASB12387B002. 000338V

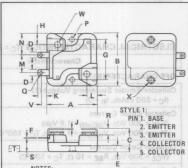
- 1. A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is
- 2. The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the terminal in the package. The torque may be increased to 50 in.-Ib if support is used to prevent rotation. The maximum penetration of the screw should be limited to 0.75".

## 200 AMPERE **NPN SILICON** POWER DARLINGTON TRANSISTOR

250 VOLTS **500 WATTS** 

## Designer's Data for "Worst-Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit datarepresenting device characteristics boundaries-are given to facilitate 'worst-case" design.



- 1. DIMENSION A AND B ARE DATUMS.
- . T. IS SEATING PLANE.
- 3. POSITIONAL TOLERANCE FOR TO BRAZE

MOUNTING HOLES ♦ 0.36 (0.014) M T AM BM

	MILLIN	ETERS	INC	INCHES		
DIM	MIN	MAX	MIN	MAX		
Α	53.09	53.84	2.090	2.120		
В	55.37	56.39	2.180	2.220		
C	-	26.67		1.050		
D	6.10	6.60	0.240	0.260		
E	6.60	7.11	0.260	0.280		
F	0.71	0.81	0.028	0.032		
G	43.3	BSC	1.70	BSC		
H	12.57	12.82	0.495	0.505		
J	1.52	1.62	0.060	0.064		
K	9.50	9.75	0.374	0.384		
L	10.21	10.46	0.402	0.412		
M	18.92	19.18	0.745	0.755		
N	23.67	23.93	0.932	0.942		
P	5.08	5.21	0.200	0.205		
0	3.53	3.78	0.139	0.149		
R.	6.76	7.26	0.266	0.286		
S	14.73	15.24	0.580	0.600		
٧	5.33	5.84	0.210	0.230		
.W	6.40	6.65	0.252	0.262		
X	7.37	7.87	0.290	0.310		

CASE 346-01

MAXIMUM RATINGS (Continued)	the state of the s		nere (	
Electrical Ratings		THE RESIDENCE		
Rating		Symbol	Value	Unit
Collector-Emitter Voltage	RANSISTOR	VCEO	250	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	ng Current	VCER	300	Vdc
Collector-Base Voltage	Intersuction and Impunious ac-	VCB	300	Vdc
Emitter-Base Voltage	nments found in switching	VEB	8.0	Vdc
Collector Current — Operating, T <sub>C</sub> = 50°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C		riov-ic i to	200 300 600 1000	high Aowar ir
Base Current — Continuous — Peak Nonrepetitive		IB	50 100	A Emitter pt
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C  For 1-minute overload	Collector	PD	500 4.0 667	Watts W/°C Watts
Operating Junction and Storage Temperature Range For 1-minute overload		T <sub>J</sub> , T <sub>stg</sub>	-55 to +150 -55 to 200	°C

	The state of the s		
FLECTRICAL	CHARACTERISTICS	(To = 25°C unless	otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	9					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 0)		V <sub>CEO(sus)</sub>	250	-	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 300 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 300 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)		ICEV	-0 -	=	2.0	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 300 Vdc, R <sub>BE</sub> = 10 Ω, T <sub>C</sub> = 100°C)	o pawer diade.	CER	insi-Collector	im3*	10	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 4.0 Vdc, I <sub>C</sub> = 0)		IEBO		-	650	mAdc

## SAFE OPERATING AREA

FBSOA	See Figure 13
RBSOA	See Figure 14 Applied of source grade
OLSOA	See Figures 16 and 17
	RBSOA

DC Current Gain (I <sub>C</sub> = 200 Adc, V <sub>CE</sub> = 5.0 Vdc)	grams	hFE	75			Unit Weight
(I <sub>C</sub> = 200 Adc, V <sub>CE</sub> = 5.0 Vdc)			90	Torries	RACTERN	AHODAMAS
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 A)	W/2°	VCE(sat)		OLANASSO O	2.0	Vdc
(I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 A, T <sub>C</sub> = 100°C)				.ame <u>6.</u> alate	2.5	e insulators ava
Base-Emitter Saturation Voltage (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 Adc) (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 Adc, T <sub>C</sub> = 100°C)		VBE(sat)	123878001	#SAAT sedmu	3.5 3.5	Vdc

## DYNAMIC CHARACTERISTICS

Output Capacitance (V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f<sub>test</sub> = 1.0 kHz) pF<sub>aled</sub>Y 4000 Cob

(1) Pulse Test. Pulse width of 300  $\mu$ s, duty cycle  $\leqslant$  2.0%.

10

20

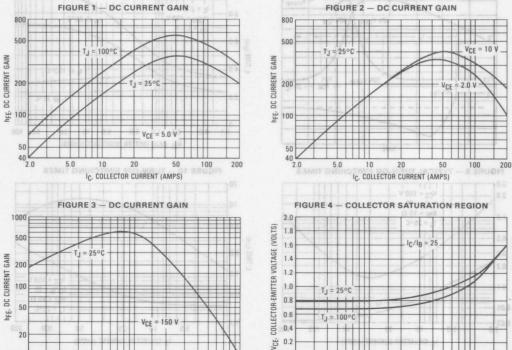
100

IC. COLLECTOR CURRENT (AMPS)

Characteristic			Symbol	Min	Тур	Max	Unit
SWITCHING CH	ARACTERISTICS	TERRETOAR	RICAL CHA	AL EFECA	TYPIC		
Resistive Load	RE 6 - EMITTER-COLLECTOR	UDFI					
Delay Time	BOATIOV CLASWROS	F.F.A.	td	Service Manual State of	0.035	0.25	μS
Rise Time	(V <sub>CC</sub> = 150 Vdc, I <sub>C</sub> = 200 A, I <sub>B</sub>	1 = 5.5 A,	tr	111-11	1.2	4.0	μS
Storage Time	R <sub>BE</sub> = 10 Ω, $t_p$ = 50 μs,		ts		6.3	20	μS
Fall Time	Duty Cycle ≤ 2.0%)		tf		2.5	8.0	μS
Inductive Load, C	Clamped	1 3					
Storage Time	(I <sub>CM</sub> = 200 A, V <sub>CEM</sub> = 150 V, R <sub>BE</sub> = 10 Ω, I <sub>B1</sub> = 5.5 A)	T.j = 100°C	tsv		9.0	30	μS
Crossover Time		13-100-0	tc		3.3	12	μS
Storage Time		T.1 = 25°C	tsv		6.5	20	μS
Crossover Time		1J=25°C	t <sub>c</sub>	75-	2.3	8.0	μS
C-E DIODE CH	IARACTERISTICS	45		BUT			
Power Dissipation	n (I <sub>B</sub> = 0)	70 8	PD	1 2507	77-1	250	W
Forward Voltage (	1) (I <sub>F</sub> = 200 A)	2	VF		1.4	2.0	V
Reverse Recovery	Time	3.0	trr		2.5	8.0	μS
(di/dt = 25 A/µ	s, I <sub>F</sub> = 200 A)	2.0	0 283	1 92		01 0	0.5
Forward Turn-On (Compliance Vo	Time ltage = 250 V, I <sub>F</sub> = 100 A)		ton	-(890)	1.0	3.5	μs
Single Cycle Surg	e Current (f = 60 Hz)	CHARAGA	IFSM	O. LECTION	CY -	500	A

(1) Pulse Test. Pulse width of 300 µs, duty cycle ≤2.0%.





1000

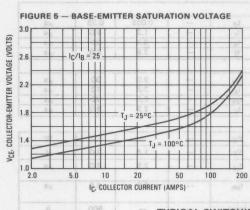
500

2.0

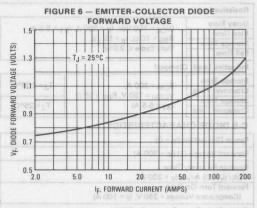
5.0

IC. COLLECTOR CURRENT (AMPS)





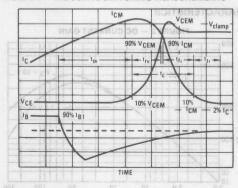
Micx



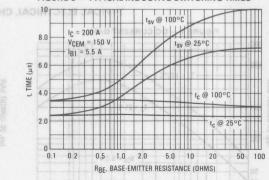
ELECTRICAL CHARACTERISTICS (Continued) Fr.c = 25°C unless otherwise no

## TYPICAL SWITCHING CHARACTERISTICS (SH 08 = 1) Ine TO D agrue a lay

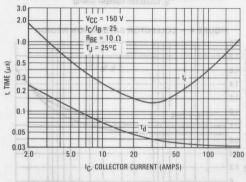
## FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS



## FIGURE 8 — TYPICAL INDUCTIVE SWITCHING TIMES

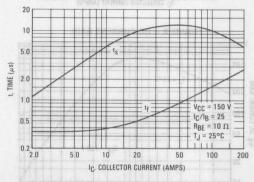


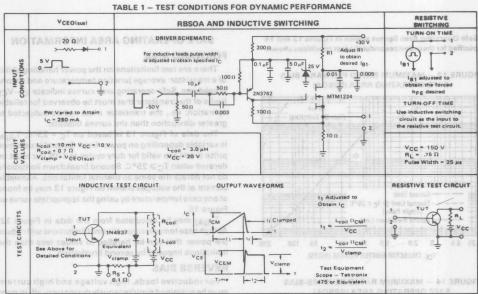




IC. COLLECTOR CURRENT (AMPS)

FIGURE 10 - TURN-OFF SWITCHING TIMES





\*Adjust – V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).

## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10 % V<sub>CEM</sub>

t<sub>rv</sub> = Voltage Rise Time, 10—90% V<sub>CEM</sub>

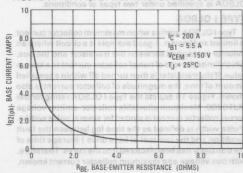
tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform

FIGURE 11 - TYPICAL PEAK REVERSE BASE CURRENT



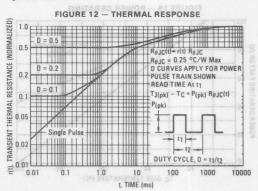
is shown in Figure 7 to aid on the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCCIC(t<sub>c</sub>)f

In general,  $t_{\Gamma V}$  +  $t_{fi}$  =  $t_{C}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

## FIGURE 13 — MAXIMUM RATED FORWARD-BIAS SAFE OPERATING AREA (FBSOA)

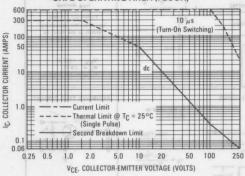


FIGURE 14 — MAXIMUM RATED REVERSE-BIAS SAFE OPERATING AREA (RBSOA)

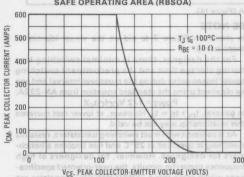
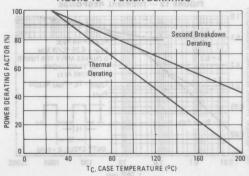


FIGURE 15 - POWER DERATING



## SAFE OPERATING AREA INFORMATION FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

 $T_{J(pk)}$  may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

## OVERLOAD SAFE OPERATING AREA

The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

## TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the MJ10200. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known,

(continued on back page)

## OVERLOAD CHARACTERISTICS

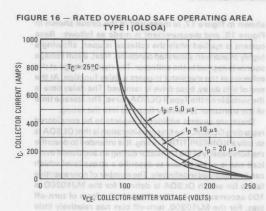


FIGURE 17 — RATED OVERLOAD SAFE OPERATING AREA
TYPE II (OLSOA)

10

8.0

T<sub>C</sub> = 25°C

10

t<sub>p</sub> = 5.0 \(\mu\)s

100

VCE. COLLECTOR-EMITTER VOLTAGE (VOLTS)

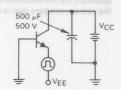
values of pulse width. A safe region of operation is thus

200

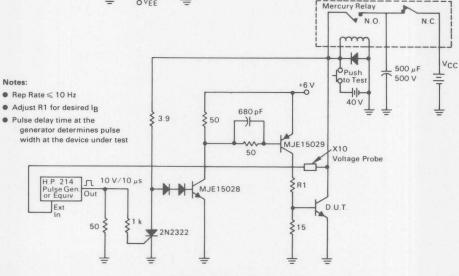
FIGURE 18 — OVERLOAD SOA TEST CIRCUIT

## Notes:

- V<sub>CE</sub> = V<sub>CC</sub> + V<sub>BE</sub>
- Adjust pulsed current source for desired I<sub>C</sub>, t<sub>p</sub>



## FIGURE 19 — OVERLOAD SOA TEST CIRCUIT TYPE II



3

## SAFE OPERATING AREA INFORMATION (continued)

## TYPE I OLSOA (continued)

Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector-emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

## TYPE II OLSOA

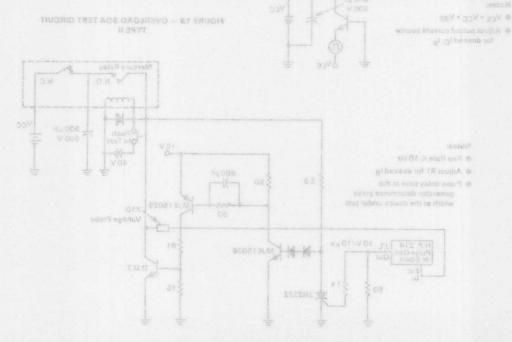
Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collector-emitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as

shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the MJ10200 is 100 occurrences. Another factor is the form of turn-off bias. For the MJ10200, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from IB2 = 0 (soft) to VBE(off) = 5 V (stiff).

OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.



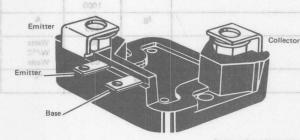
MAXIMUM BATINGS (Co.

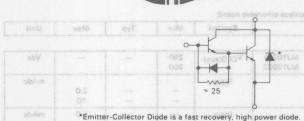


## Designer's Data Sheet

## 50 KVA HIGH SPEED SWITCHMODE TRANSISTOR 200-Ampere Operating Current

The MJ10201 Darlington transistor is designed for industrial service under practical operating environments requiring fast switching speed for highly efficient systems operating at high frequency such as inverters, PWM controllers and other high frequency system operating from 120 V lines or batteries.





## MAXIMUM RATINGS

Mechanical Ratings			
Rating			
Mounting Torque (To heat sink with 10-32 Screw) (Note 1)			
ac	20	inlb	
08	120	grams	
	76	ac 3 20	

Thermal Resistance, Junction to Case,  $R_{ heta JC}$  0.25 °C/W

Mica Insulators available as separate items. 0.003" thick. Motorola Part Number B12387B001. 0.006" thick. Motorola Part Number B12387B002.

### Notes

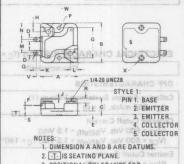
- A Belleville washer of 0.472" O.D., 0.205" I.D., 0.024" thick and 150 pounds flat is recommended such as P/N AM125206 available from National Disc Spring Div., 385 Hillside Ave., Hillside N.J. 07205.
- The lead torque should be limited to 20 in.-lb, unsupported to prevent rotation of the terminal
  in the package. The torque may be increased to 50 in.-lb if support is used to prevent
  rotation. The maximum penetration of the screw should be limited to 0.75".

# 200 AMPERE Activated NPN SILICON POWER DARLINGTON TRANSISTOR

(amric 0) 200 and 250 VOLTS 500 WATTS

## Designer's Data for d'Worst-Case' Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data—representing device characteristics boundaries—are given to facilitate "worst-case" design.



- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLES:
- ♦ 0.36 (0.014)⊗ T A⊗ B⊗
   4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

			20	12 hon
	MILLIN	ETERS	INC	HES
DIM	MINS	MAX	MIN	MAX
A	53.09	53.84	2.090	2.120
B	55.37	56.39	2.180	2.220
C	(ab¥ 0	26.67	V sbA	1.050
D	6.10	6.60	0.240	0.260
E	6.60	7.11	0.260	0.280
(E)	0.71	0.81	0.028	0.032
G	43.3	1 BSC	1.70	BSC
H	12.57	12.82	0.495	0.505
J	1.52	1.62	0.060	0.064
K	9.50	9.75	0.374	0.384
L	10.21	10.46	0.402	0.412
M	18.92	19.18	0.745	0.755
N	23.67	23.93	0.932	0.942
P	5.08	5.21	0.200	0.205
0	3.53	3.78	0.139	0.149
R	6.76	7.26	0.266	0.286
S	14.73	15.24	0.580	0.600
V	5.33	5.84	0.210	0.230
W	6.40	6.65	0.252	0.262
X	7.37	7.87	0.290	0.310

CASE 346-01

(M) MOTOROLA

MAXIMUM RATINGS (Continued)			my Fall	
Electrical Ratings A 003	(1) A Maria Control of the Control o		end of the earth	
MOOLIE WHA Rating	MODE TRANSISTOR	Symbol	Value	Unit
Collector-Emitter Voltage	MJ10201 MJ10202	VCEO	250 200	Vdc
Collector-Emitter Voltage (RBE = 10 Ohms)	r is designed for industrial	VCER	300	Vdc
Collector-Base Voltage	intranments requiring tast	VCB	300	Vdc
Emitter-Base Voltage	controllers and other high	VEB	8.0	Vdc
Collector Current — Operating, T <sub>C</sub> = 50°C — Continuous, T <sub>C</sub> = 25°C — Peak Repetitive, T <sub>C</sub> = 25°C — Peak Nonrepetitive, T <sub>C</sub> = 25°C	V lines or battories.	OST ICON B	200 300 600 1000	A
Base Current — Continuous  — Peak Nonrepetitive		IB	50 100	A
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C For 1-minute overload	10739(10.7)	PD	500 4.0 667	Watts W/°C Watts
Operating Junction and Storage Temperature R For 1-minute overload	ange	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150 -55 to +200	°C

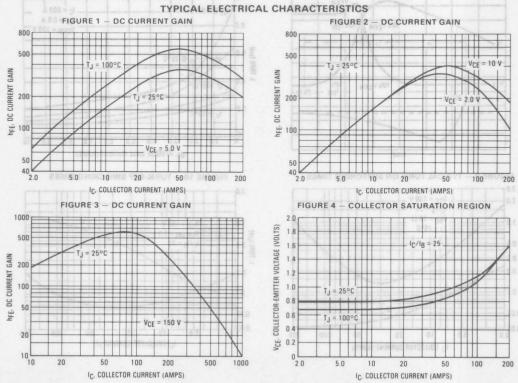
ELECTRICAL	CHARACTERISTICS	(Tc = 25°C unless otherwise noted)	

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS			-0			
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 0)	MJ10201 MJ10202	VCEO(sus)	250 200	-	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 500 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = 500 Vdc, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 150°C)		ICEV	Ξ	=	2.0 10	mAdc
Emitter Cutoff Current (VEB = 4.0 Vdc, I <sub>C</sub> = 0)	power dicule.	IEBO	de is a feet	ord vorselloS-1	5.0	mAdc
SAFE OPERATING AREA					ROUTE	SE MILIERO
Second Breakdown Collector Current with Base F	orward-Biased	FBSOA		See Figure 1	3 Aprill	e5i Isokuade
Clamped Inductive SOA with Base Reverse-Biase	RBSOA	See Figure 14				
Overload SOA	di-ni	OLSOA	See Figures 16 and 17			
ON CHARACTERISTICS (1)						(f adv
DC Current Gain (I <sub>C</sub> = 200 Adc, V <sub>CE</sub> = 5.0 Vdc)	81-10	hFE	75	/4-20 Seraw	rithw aud or b	Yorque (Lea se 2)
(I <sub>C</sub> = 200 A, V <sub>CE</sub> = 10 V)	grams	120	90	_	_	ariginalizated
Collector-Emitter Saturation Voltage		V <sub>CE(sat)</sub>		8.0116.8	ARACTERN	Vdc 49
(I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 A) (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 A, T <sub>C</sub> = 100°C)		0.25		OLSR <u>ess</u>	2.0 2.5	net Register
Base-Emitter Saturation Voltage (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 Adc) (I <sub>C</sub> = 200 Adc, I <sub>B</sub> = 5.5 Adc, T <sub>C</sub> = 100°C)		VBE(sat)	=	1600182019 1001 1600182019 1002	3.5 3.5	Vdc
DYNAMIC CHARACTERISTICS	ai sell abassa	DRF has dealer 160	ses ar	800 a -0 to -0	CE O to carrie	o active than J
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	c Spring Div.,		wollande for	AM125206 U 07856		pF
(1) Pulse Test. Pulse width of 300 μs, duty cycle ≤2.0%.	Insverse of hea	Ib if support is u	mi Oč ot 5	etology at you	n outpost effici	rasimala erit r

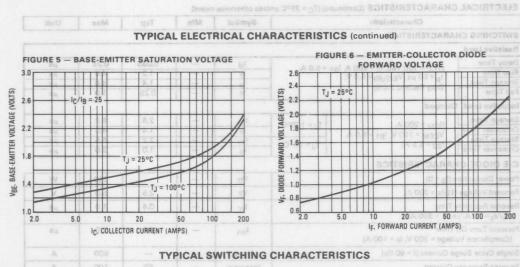
ELECTRICAL CHARACTERISTICS (Continued) (T<sub>C</sub> = 25°C unless otherwise noted)

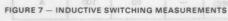
Characteristic		Symbol	Min	Тур	Max	Unit	
SWITCHING CH	ARACTERISTICS	RACTERISTI	HOAL CHA	TOBUS	TYPICAL		
Resistive Load	GATALLIAN STERRING A SO	110410					
Delay Time	0/ - 150 VI- 1 - 200 A I	-554	t <sub>d</sub>	DUY SIC	0.035	0.25	μS
Rise Time	$(V_{CC} = 150 \text{ Vdc}, I_C = 200 \text{ A}, I_B t_D = 50 \mu \text{s}, V_{BE(off)} = 5.0 \text{ V},$	1 - 5.5 A,	tr	DITT.	1.2	4.0	μS
Storage Time	Duty Cycle ≤ 2.0%)		ts		1.4	4.0	μS
Fall Time	Duty Cycle & 2.076)		tf		0.25	1.0	μѕ
Inductive Load, (	Clamped	1 3					
Storage Time	(I <sub>CM</sub> = 200 A, V <sub>CEM</sub> = 150 V, I <sub>B1</sub> = 5.5 A,	T <sub>J</sub> = 100°C	t <sub>sv</sub>		2.8	8.0	μs
Crossover Time		113-100 C	t <sub>c</sub>		1.4	4.0	μs
Storage Time	IB2 = 5.5 A)	T1= 25°C	tsv		2.2	6.5	μS
Crossover Time	18Z - 3.3 A)	13-20 0	tc	NH-III	1.0	3.0	μs
C-E DIODE CH	HARACTERISTICS	., 8			1 3-67 = 0		
Power Dissipation	n (I <sub>B</sub> = 0)	- ×	PD		-	250	W
Forward Voltage	(1) (I <sub>F</sub> = 200 A)	200	VF	1 +1"	2.5	5.0	V
Reverse Recovery	/ Time	l lan	t <sub>rr</sub>		0.4	1.0	μS
$(d_i/d_t = 25 A/\mu)$	s, I <sub>F</sub> = 200 A)		200	04 04	20	01	18 03
Forward Turn-On (Compliance Vo	Time oltage = 200 V, I <sub>F</sub> = 100 A)		ton	- (8)	VA) 1/ 0.4 0 10	1.0	μS
Single Cycle Surg	ge Current (f = 60 Hz)	CHARACTER	IFSM	ICAL S	977 -	500	А
Reverse Recovery	y Current dt = 200 A/μs)	UDIS	IRM(REC)	Wadiisa	50	100	A T SAU

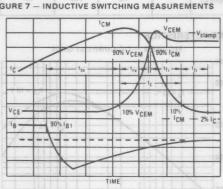
(1) Pulse Test. Pulse width  $\leqslant$  300  $\mu$ s, duty cycle  $\leqslant$  2.0%.

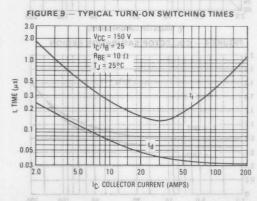




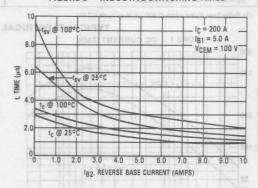


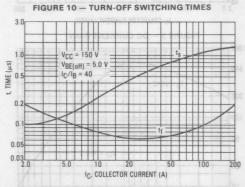






#### FIGURE 8 — INDUCTIVE SWITCHING TIMES





VCEO(sus) **RBSOA AND INDUCTIVE SWITCHING** SWITCHING TURN ON TIME o +V Drive 20 (1 DRIVER SCHEMATIC de Orderecire 0.005 μ1 RB \$10 + CONDITIONS 0 0.005 2N3762 10 B1 adjusted to obtain the forced T10 µF HP214 IN MTM14N05 ₹10 h<sub>FE</sub> desired TURN-OFF TIME 38 V PW Varied to Attain Islana It and 50 0.05 µF Use inductive switching circuit as the input to the resistive test circuit I<sub>C</sub> = 250 mA 2.0 uF destion than the ₹50 \$1000 \$100 Lcoil = 10 mH VCC = 10 V L<sub>coil</sub> = 3.0 µH V<sub>CC</sub> = 150 V R<sub>L</sub> = 0.75 Ω Pulse Width = 25 μs VCC = 20 V MTM14N05 R<sub>coil</sub> = 0.7 m V<sub>clamp</sub> = V<sub>CEO(sus)</sub> VERT E INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to Obtain Ic TEST CIRCUITS Tul data in Fi VCC 01 1N4937 Lcoil (ICM) gasi a Input or V<sub>clamp</sub> See Above for V<sub>clamp</sub> VCE **Detailed Conditions** VCEM Test Equipment I ORS Scope - Tektronix 475 or Equivalent Time

TABLE 1 - RBSOA AND INDUCTIVE SWITCHING DRIVER SCHEMATIC

\*Adjust - V such that VBE(off) = 5 V except as required for RBSOA (Figure 14).

#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and motor controls, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10 % V<sub>CEM</sub>

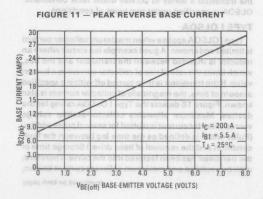
trv = Voltage Rise Time, 10-90% VCEM

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the inductive switching waveform



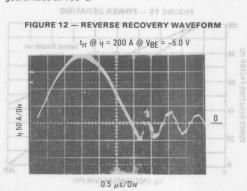
is shown in Figure 7 to aid on the visual identity of

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCCIC(t<sub>C</sub>)f

In general,  $t_{\text{FV}}$  +  $t_{\text{fi}}$  =  $t_{\text{C}}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

FIGURE 13 — MAXIMUM RATED FORWARD-BIAS SAFE OPERATING AREA (FBSOA)

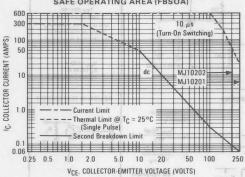


FIGURE 14 — MAXIMUM RATED REVERSE BIAS SAFE OPEATING AREA (RBSOA)

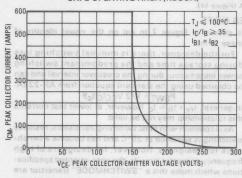
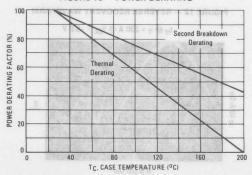


FIGURE 15 - POWER DERATING



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15

 $T_{J(pk)}$  may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse-Bias Safe Operating Area and represents the voltage-current condition allowable during reverse-biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

#### **OVERLOAD SAFE OPERATING AREA**

The forward-bias safe operating area (FBSOA) specification given in Figure 13 adequately describes transistor capability for normal repetitive operation. When short circuit or fault conditions occur, these transistor specifications are not always adequate. A specification called overload safe operating area (OLSOA) has been developed to describe the transistor's ability to survive under fault conditions. OLSOA is specified under two types of conditions.

#### TYPE I OLSOA

Type I OLSOA applies when maximum collector current is limited and known. A good example is a circuit where an inductor is inserted between the transistor and the bus, which limits the rate of rise of collector current to a known value. If the transistor is then turned off within a specified amount of time, the magnitude of collector current is also known. Figure 16 depicts the Type I OLSOA rating for the devices. Maximum allowable collector-emitter voltage versus collector current is plotted for several pulse widths. (Pulse width is defined as the time lag between the fault condition and the removal of base drive.) Storage time of the transistor has been factored into the curve. Therefore, with bus voltage and maximum collector current known,

(continued on back page)

= 5.0 µs

200

FIGURE 17 - RATED OVERLOAD SAFE OPERATING AREA

TYPE II (OLSOA)

20 μs -

100

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

TC = 25°C

#### OVERLOAD CHARACTERISTICS

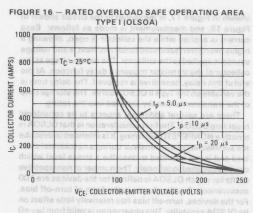
8.0

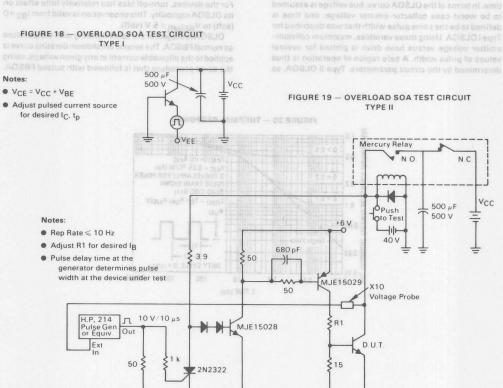
6.0

4.0

0

BASE CURRENT (AMPS)





#### TYPE I OLSOA (continued)

Figure 16 defines the maximum time which can be allowed for fault detection and shutdown of base drive.

Type I OLSOA is measured in a common-base circuit (Figure 18) which allows precise definition of collector emitter voltage and collector current. This is the same circuit that is used to measure forward-bias safe operating area.

#### TYPE II OLSOA

Type II OLSOA applies when maximum collector current is not limited by circuit design, but is limited only by the gain of the transistor. Therefore, collector current does not appear on the Type II OLSOA curve. This curve defines a safe region of operation from the information that is usually available to the designer.

This information is normally base drive, bus voltage and time. In terms of the OLSOA curve, bus voltage is assumed to be worst-case collector-emitter voltage, and time is defined to be the same pulse width that was described for Type I OLSOA. Using these variables, maximum collector-emitter voltage versus base drive is plotted for several values of pulse width. A safe region of operation is thus determined by the circuit parameters. Type II OLSOA, as

shown in Figure 17, is measured in the circuit shown in Figure 19, and measurement is made as follows: Base current is applied while the collector is open, allowing a highly overdriven saturated condition. Next, a stiff voltage source is applied to the collector. The rising voltage at the collector of the transistor triggers a delay function. At the end of this delay, base drive is removed. The delay time is the variable on the Type II OLSOA curve. The storage time of the transistor is thereby factored into the rating.

There are several additional aspects to be considered regarding OLSOA. The first consideration is that OLSOA is strictly a NONREPETITIVE rating. It is intended to describe the survivability of the transistor during an accidental overload and is not intended to describe a stress level which can be sustained indefinitely. The number of nonrepetitive faults for which OLSOA is defined for the devices are 100 occurrences. Another factor is the form of turn-off bias. For the devices, turn-off bias has relatively little effect on its OLSOA capability. This observation is valid from IB2 = 0 (soft) to VBE(off) = 5 V (stiff).

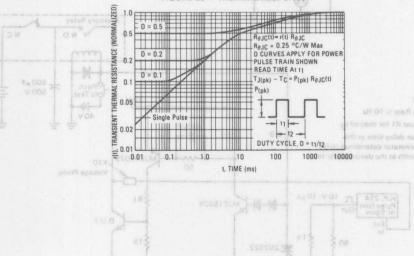
OLSOA is subject to the same derating with temperature as normal FBSOA. The second breakdown derating curve is applied to the allowable current at any given voltage, using the same procedure that is followed with pulsed FBSOA.

VCE = VCC + VBE
Adjust pulsed current source

Adjust pulsed current source



SAFE OPERATING AREA INFORMATION (continued)



# MOTOROLA

# MJ11011, MJ11013, MJ11015

ELECTRIC NPN BACTERISTICS

# MJ11012, MJ11014, MI11016

#### HIGH-CURRENT COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain hFE = 1000 (Min) @ IC = 20 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor
- Junction Temperature to +200°C

30 AMPERE

DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

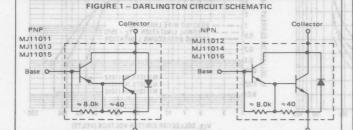
> 60-120 VOLTS 200 WATTS

#### MAXIMUM RATINGS

Rating	Symbol		MJ11013 MJ11014		Unit
Collector-Emitter Voltage	VCEO	60	90	120	Vdc
Collector-Base Voltage	VCB	60	90	120	Vdc
Emitter-Base Voltage	VEB		5		Vdc
Collector Current	IC		30	4.869	Adc
Base Current	I <sub>B</sub>		1	9 5	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$ @ $T_C = 100^{\circ}C$	PD		200 1.15	7 0 0 0	Watts W/OC
Operating and Storage Junction Temperature Range	TJ,T <sub>stg</sub>		-55 to +20	0	°C

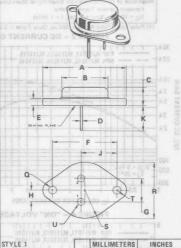
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.87	°C/W	
Maximum Lead Temperature for Soldering Purposes for ≤ 10 Seconds.	20 jT 50	01275 💃	oC.	



st not be subjected to greater at ion to

9



E 1		10113	MILLIN	METERS	INC	HES
1.	BASE	DIM	MIN	MAX	MIN	MAX
2.	EMITTER	A		39.37	17-	1,550
SE	COLLECTOR	В		21.08	int-	0.830
		C	6.35	7.62	0.250	0.300
		D	0.97	1.09	0.038	0.043
		E	1.40	1.78	0.055	0.070
		F	29.90	30.40	1.177	1.197
		G	10.67	11.18	0.420	0.440
	(In) (In)	H	5.33	5.59	0.210	0.220
		J	16.64	17.15	0.655	0.675
	1 (00)33	K	11.18	12.19	0.440	0.480
	The state of the s	0	3.81	4.19	0.150	0.165
Н		R		26.67		1.050
		U	2.54	3.05	0.100	0.120
				CASE 1-	04	

1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.

Emitter

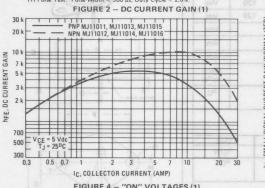
M MOTOROLA

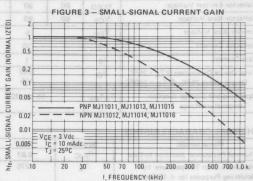
ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted.)

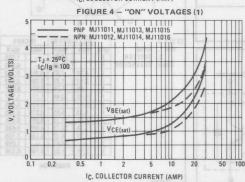
WELLVILL WELLVLLY

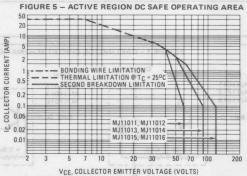
Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ11011,MJ11012 MJ11013,MJ11014 MJ11015,MJ11016		BVCEO	60 90 120	-	Vdc
Collector Emitter Leakage Current $(V_{CE} = 60 \text{ Vdc}, R_{BE} = 1 \text{ k ohm})$ $(V_{CE} = 90 \text{ Vdc}, R_{BE} = 1 \text{ k ohm})$	MJ11011,MJ11012 MJ11013,MJ11014		ICER	_	1 1	mAdc
(VCE = 120 Vdc, RBE = 1 k ohm) (VCE = 80 Vdc, RBE = 1 k ohm, TC = 150°C) (VCE = 90 Vdc, RBE = 1 k ohm, TC = 150°C) (VCE = 120 Vdc, RBE = 1 k ohm, TC = 150°C)	MJ11015,MJ11016 MJ11011,MJ11012 MJ11013,MJ11014 MJ11015,MJ11016		OMPLEM ANSISTO	RRENT C	5 UO 5 D M	
Emitter Cutoff Current (VBE = 5 Vdc, IC = 0)	9801	tary general purp	IEBO	or seminop	200/162 45 5	mAdc
Collector-Emitter Leakage Current (VCE = 50 Vdc, I <sub>B</sub> = 0)		0 to = 20 Ado	ICEO	= 224 - 6	1 Carrent Gai	mAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I <sub>C</sub> = 20 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 30 Adc, V <sub>CE</sub> = 5 Vdc)		1917(01)	pŁĘ	1000 200	ic Construct Resistor	Menorali Shunt
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 200 mAdc) (I <sub>C</sub> = 30 Adc, I <sub>B</sub> = 300 mAdc)			VCE(sat)	000004-63 9	3 4	Vdc
Base-Emitter Saturation Voltage IC = 20 Adc, IB = 200 mAdc) IC = 30 Adc, IB = 300 mAdc)			VBE(sat)	-	3.5 5	Vdc
DYNAMIC CHARACTERISTICS		MILLIAN IN SE	1.5% [5]			
Magnitude of Common Emitter Small-Signal Sho Forward Current Transfer Ratio (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3 Vdc, f = 1 MHz)		MATTOTA MATTOTE	lh <sub>fe</sub> l	4 esmys	ings	MHz

(1) Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.









There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate  $I_C$ – $V_{CE}$  limits of the transistor that must be observed for reliable operation; e.g., the transistor

must not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



#### **COMPLEMENTARY DARLINGTON** SILICON POWER TRANSISTORS

. . . designed for use as general purpose amplifiers, low frequency switching and motor control applications.

- High dc Current Gain @ 10 Adc hff = 400 Min (All Types)
- Collector-Emitter Sustaining Voltage

VCEO(sus) = 150 Vdc (Min) - MJ11018, 17

= 200 Vdc (Min) — MJ11020, 19 = 250 Vdc (Min) - MJ11022, 21

Low Collector-Emitter Saturation

VCE(sat) = 1.0 V (Typ) @ IC = 5.0 A = 1.8 V (Typ) @ Ic = 10 A

- Monolithic Construction
- 100% SOA Tested @ V<sub>CE</sub> = 44 V, I<sub>C</sub> = 4.0 A, t = 250 ms.

#### 15 AMPERE

#### DARLINGTON **POWER TRANSISTORS COMPLEMENTARY SILICON**

150, 200, 250 VOLTS 175 WATTS



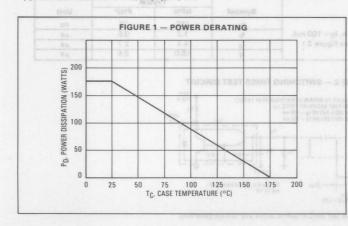
#### **MAXIMUM RATINGS**

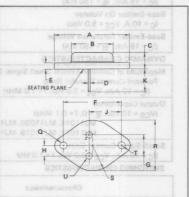
Rating	Symbol	MJ11018 MJ11017	MJ11020 MJ11019	MJ11022 MJ11021	Unit
Collector-Emitter Voltage	VCEO	150	200	250	Vdc
Collector-Base Voltage	V <sub>CB</sub>	150	200	250	Vdc
Emitter-Base Voltage	VEB		5.0		Vdc
Continuous Peak	lc		15	fiu	Adc
Base Current	I <sub>B</sub>		0.5		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate Above 25°C	PD		175 1.16		Watt W/°0
Operating and Storage Junction Temperature Range	T <sub>J</sub> T <sub>stg</sub>		-65 to +175 -65 to +200		°C °C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.86	°C/W

(1) Pulse Test: Pulse Width 5.0 ms, Duty Cycle ≤ 10%





STYLE 1 PIN 1. BASE 2. EMITTER
CASE COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	-	1,550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.97	1.09	0.038	0.043
E	1.40	1.78	0.055	0.070
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.81	4.19	0.150	0.165
R	-	26.67	-	1.050
U	2.54	3.05	0.100	0.120

CASE 1-04

NOTES: 1. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-3 OUTLINE SHALL APPLY.



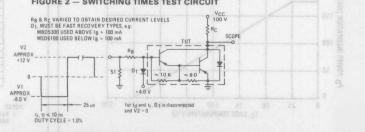


3839MA Characteristics		Symbol	Min	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 0.1 Adc, I <sub>B</sub> = 0) MJ11017, MJ1 MJ11019, MJ11 MJ11021, MJ11	020	frequency	VCEO(sus)	150 200 250	SILICON ed for use as g	Vdc
Collector Cutoff Current		ICEO	rol application p 10 Ado — ha rining Voltage		made	
Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 1.5 Vdc) (V <sub>CE</sub> = Rated V <sub>CB</sub> , V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>J</sub> = 15	50°C)		ICEV OSC	LM — (niM)	0.5 5.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			IEBO	Satura <u>a</u> rion (@ lc = 5.0 A	2.0	mAdc
ON CHARACTERISTICS (1)				A01=310A	qyT) V 8.1 =	
DC Current Gain (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 5.0 Vdc)		.8:	#FE 4.0 A, t = 250 m	400	15,000 AO	ilonoi4 *
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 100 mA) (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 150 mA)	1		VCE(sat)	=	2.0	Vdc
Base-Emitter On Voltage I <sub>C</sub> = 10 A, V <sub>CE</sub> = 5.0 Vdc)	rigeta	YSOTT UM	VBE(on)	Little towning	2.8	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 150 mA)	ct/V	260	V <sub>BE(sat)</sub>	807	3.8	Vdc
DYNAMIC CHARACTERISTICS				-1-87		9,0000 0000 10
Magnitude of Common Emitter Small Signal St Forward Current Transfer Ratio (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 MHz)	nort Circ	uit	be [hfe]	3.0	2022 2 2	Minucos Perki Currant
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz) MJ11018, MJ11020, MJ11 MJ11017, MJ11019, MJ11			er i Cob	CT ONE	400 600	oras »PFA erecutor Stores Stores Rengel
Small-Signal Current Gain (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 kHz	110	10	h <sub>fe</sub>	100	olinium nuo	RAHO JAMR

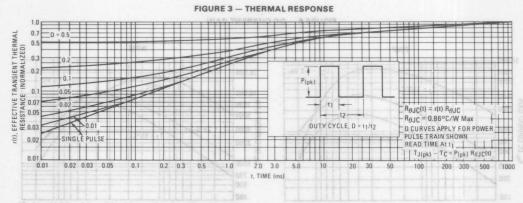
			Тур	help 1 death	
	Characteristics	Symbol	NPN	PNP	Unit
Delay Time	1 31545	td	150	75	ns
Rise Time	(VCC = 100 V, IC = 10 A, IB = 100 mA	tr	1.2	0.5	μς
Storage Time	NOTES AND AND VBE(off) = 5.0 V) (See Figure 2.)	ts	4.4	2.7	μS
Fall Time		tf	10.0	2.5	μS

(1)Pulsed Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.

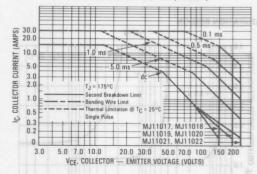
## FIGURE 2 — SWITCHING TIMES TEST CIRCUIT



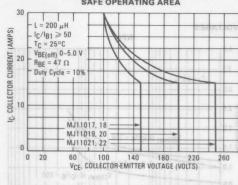
For NPN test circuit reverse diode and voltage polarities.



# FIGURE 4 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA (FBSOA)



#### FIGURE 5 — MAXIMUM RBSOA, REVERSE BIAS SAFE OPERATING AREA



#### FORWARD BIAS

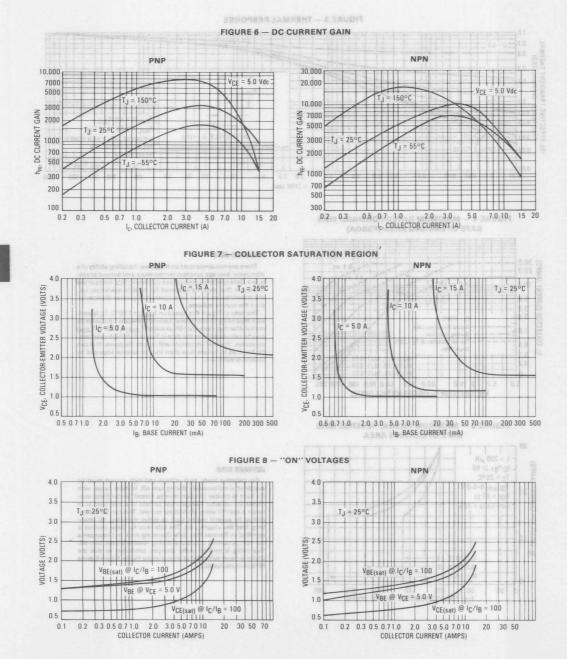
There are two limitations on the power handling ability of a transistor: average junction temperature and second break-down. Safe operating area curves indicate Ic VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

than the curves indicate. The data of Figure 4 is based on  $T_J(pk)$  = 175°C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{50}$  provided  $T_J(pk)$  =  $175^{50}$ C.  $T_J(pk)$  may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubsing, load line shaping, etc. The safe level for these devices is specified as Reverse Blas Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalenche mode. Figure 5 gives RSSOA characteristics.







#### HIGH-CURRENT COMPLEMENTARY SILICON TRANSISTORS

... for use as output devices in complementary general purpose amplifier applications.

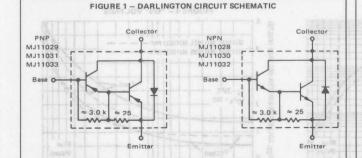
- High DC Current Gain hFE = 1000 (Min) @ IC = 25 Adc hFE = 400 (Min) @ IC = 50 Adc
- Curves to 100 A (Pulsed)
- Diode Protection to Rated Ic.
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor
- Junction Temperature to +200°C

#### MAXIMUM RATINGS

Rating 0.8	Symbol			MJ11032 MJ11033	Unit
Collector-Emitter Voltage	VCEO	60	90	120	Vdc
Collector-Base Voltage	VCB	60	90	120	Vdc
Emitter-Base Voltage	VEB		5		Vdc
Collector Current-Continuous Peak	I <sub>C</sub>		50 100		Adc
Base Current-Continuous	IB	are two	31002		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C @ T <sub>C</sub> = 100°C	PD	istor: aver le operatie	000		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	post notel	55 to +20	00	°C

#### THERMAL CHARACTERISTICS

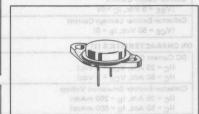
Characteristic	Symbol	Max	Unit	
Maximum Lead Temperature for Soldering Purposes for ≤ 10 seconds	mit s.T.Lessta a	275	°C	
Thermal Resistance Junction to Case	$R_{\theta}JC$	0.584	°C	

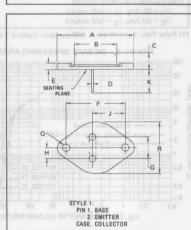


#### 50 AMPERE

#### COMPLEMENTARY SILICON DARLINGTON POWER TRANSISTOR

60-120 VOLTS 300 WATTS - V 00 = 30 V





	MILLIN	IETERS		HES
DIM	MIN	MAX	MIN	MAX
A	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

(TO-3 Except Pin Diameter)





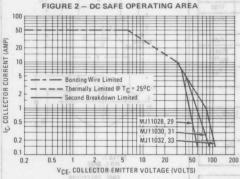
#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ11028 MJ11029 MJ11030 MJ11031 MJ11032 MJ11033		60 90 120	=	Vdc
Collector-Emitter Leakage Current (VCE = 60 Vdc, RBE = 1 k ohm) (VCE = 90 Vdc, RBE = 1 k ohm) (VCE = 120 Vdc, RBE = 1 k ohm) (VCE = 60 Vdc, RBE = 1 k ohm, TC = 150°C) (VCE = 90 Vdc, RBE = 1 k ohm, TC = 150°C) (VCE = 120 Vdc, RBE = 1 k ohm, TC = 150°C)	MJ11030 MJ11031	sentary general	Ξ	2 niveb 12utuo 2	amplifier app
Emitter Cutoff Current (VBE = 5 Vdc, IC = 0)		A OSIEBO 9	FE = 400 (Min	(longles) A 001	mAdc
Collector-Emitter Leakage Current (V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)		ICEO	- al	2	mAdc
ON CHARACTERISTICS (1)	Resistor	a-Emitter Shund-	nh duit-in Bas	w neithering)	Monontana
DC Current Gain (I <sub>C</sub> = 25 Adc, V <sub>CE</sub> = 5 Vdc) (I <sub>C</sub> = 50 Adc, V <sub>CE</sub> = 5 Vdc)		hFE	1 k 400	18 k	nerra <u>n</u> ut •
Collector-Emitter Saturation Voltage ( $I_C = 25 \text{ Adc}$ , $I_B = 250 \text{ mAdc}$ ) ( $I_C = 50 \text{ Adc}$ , $I_B = 500 \text{ mAdc}$ )		VCE(sat)	-	2.5 3.5	Vdc
Base-Emitter Saturation Voltage		VRE/cat)			Vdc

(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

(IC = 25 Adc, IB = 200 mAdc)

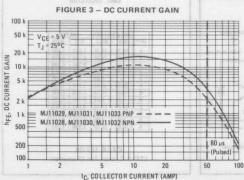
(IC = 50 Adc, IB = 300 mAdc)

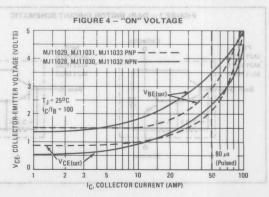


There are two limitations on the power-handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

3.0

The data of Figure 2 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second break-







#### Designers Data Sheet

#### HORIZONTAL DEFLECTION TRANSISTOR

... specifically designed for use in large screen color deflection circuits.

- Collector-Emitter Voltage –
   VCEX = 1500 Volts
- Glassivated Base-Collector Junction
- Forward Bias Safe Operating Area @ 50 μs = 15 A, 300 V
- Switching Times with Inductive Loads t<sub>f</sub> = 0.65 μs (Typ) @ I<sub>C</sub> = 2.0 A

2.5 AMPERE
NPN SILICON
POWER TRANSISTOR

1500 VOLTS 75 WATTS

Designer's Data for "Worst Case" Conditions

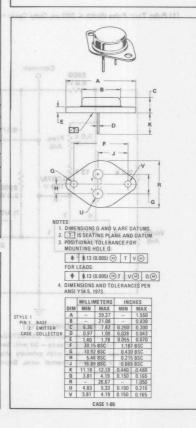
The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

#### MAXIMUM RATINGS

Rating	Symbol	Value 0.8	Unit
Collector-Emitter Voltage	V <sub>CEO</sub> (sus)	750	Vdc
Collector-Emitter Voltage	VCEX	1500	Vdc
Emitter-Base Voltage	VEBO	5.0	Vdc
Collector Current — Continuous	lc	2.5	Adc
Base Current — Continuous	I IB	2.0	Adc
Emitter Current — Continuous	I <sub>E</sub>	4.5	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	75 30 0.6	Watts Watts W/OC
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Word Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.67	°C/W
Maximum Lead Temperature for Soldering	4.29 THE	A 275	°C
Purposes: 1/8" from Case for 5 Seconds	2.18 mm 1	1.8	1

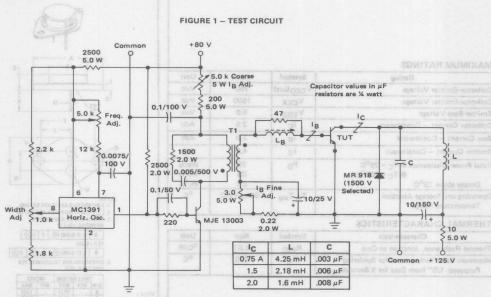




#### ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Sustaining Voltage (IC = 50 mAdc, IB = 0)	VCEO(sus)	750	-	_	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 1500 Vdc, V <sub>BE</sub> = 0)	ICES		160731	1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	IEBO			0.1	mAdc
ON CHARACTERISTICS (1)	BOTS	DIABLE ME	OFFI SCTIO	ORIZONTAL	14
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 1.8 Adc)	V <sub>CE(sat)</sub>	-		5.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 1.8 Adc)	V <sub>BE(sat)</sub>		2 SH 980 101	1.5	Vdc
Second Breakdown Collector Current with Base-Forward Biased	I <sub>S/B</sub>		See Figure 14	tioV rottimS-rot	ello3 #
DYNAMIC CHARACTERISTICS				EX = 1500 Volt	5V
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	C <sub>ob</sub>	-	50	rated See Colle	pF
Current Gain — Bandwidth Product (1) (I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	fT		4.0	oing Times with	MHz
SWITCHING CHARACTERISTICS			11c = 2.0 A	0.65 µs (Typ) 6	10
Fall Time (I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 1.0 Adc, L <sub>B</sub> = 12 \(mu \text{H}\), See Figure 1)	tf	-	0.65	1.0	μs

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.



DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A-05-1/4" laminate "E" iron core. Primary Inductance — 39 mH. Secondary Inductance — 22 mH, Leakage Inductance with primary shorted — 2.0  $\mu$ H, Primary 260 turns #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

By now, the concept of controlling the shape of the turn-off base current is widely accepted and applied in horizontal deflection design. The problem stems from the fact that good saturation of the output device, prior to turn-off, must be assured. This is accomplished by providing more than enough IB1 to satisfy the lowest gain output device heE at the end of scan ICM. Worst case component variations and maximum high voltage loading must also be taken into account.

If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Figure 2. This results in rapid, but only partial, collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Figure 3, thus allowing excess carrier recombination in the collector to occur while the base current is still flowing.

Choosing the right LB is usually done empirically, since the equivalent circuit is complex, and since there are several important variables (ICM, IB1, and hFE at ICM). One method is to plot fall time as a function of LB, at the desired conditions, for several devices within the hff specification. A more informative method is to plot power dissipation versus IB1 for a range of values of LB as shown in Figures 4 and 5. This shows the parameter that really matters, dissipation, whether caused by switching or by saturation. The negative slope of these curves at the left (low IB1) is caused by saturation losses. The positive slope portion at higher IB1, and low values of LB is due to switching losses as described above. Note that for very low LB a very narrow optimum is obtained. This occurs when IB1 hFE = ICM, and therefore would be acceptable only for the "typical" device with constant ICM. As LB is increased, the curves become broader and flatter above the IB1 hFE = ICM point as the turn-off "tails" are brought under control. Eventually, if LB is raised too far, the dissipation all across the curve will rise, due to poor initiation of switching rather than tailing. Plotting this type of curve family for devices of different her, essentially moves the curves to the left or right according to the relation IB1 hFE = constant. It then becomes obvious that, for a specified ICM, an LB can be chosen which will give low dissipation over a range of hFE and/or IB1. The only remaining decision is to pick IB1 high enough to accommodate the lowest hFE part specified. Figure 8 gives values recommended for LB and IB1 for this device Neither LB nor IB1 are absolutely critical, as can be seen from the examples shown, and values of Figure 8 are provided for guidance only.

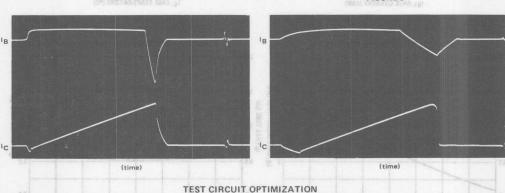
FIGURE 4 - OPTIMIZING DRIVE 0 to = 0.75 A

over a wide range of ICM. These values were chosen from a large number of curves like Figure 4 and Figure 5.

#### TEST CIRCUIT WAVEFORMS

FIGURE 2

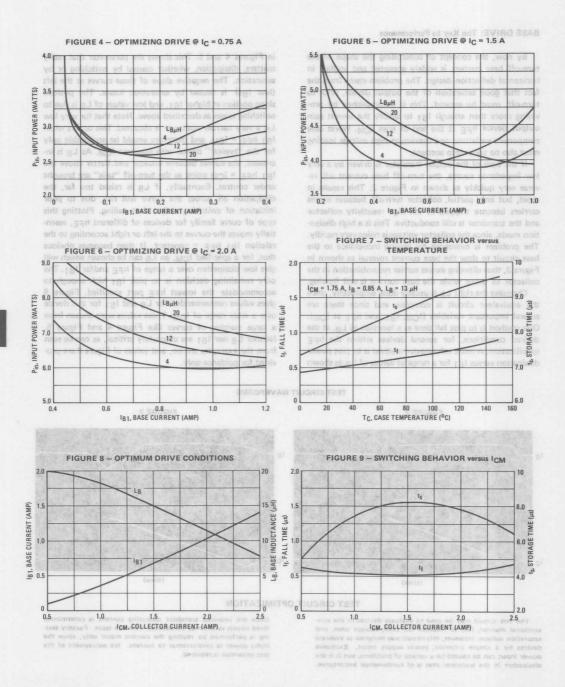
FIGURE 3



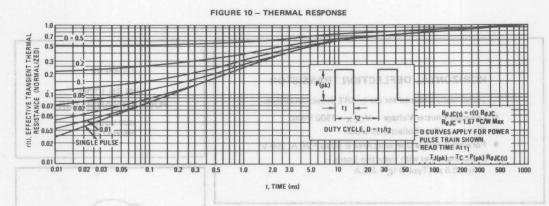
The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the

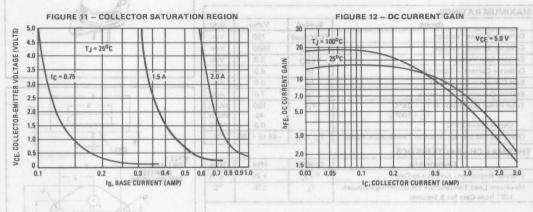
dissipation in the transistor that is of fundamental importance.

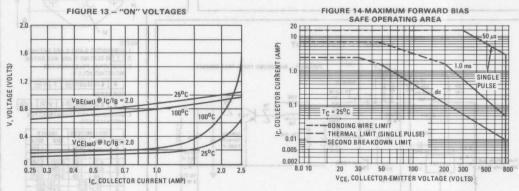
Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the inplut power is proportional to current. No adjustment of the test apparatus is required











NOTE:
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> — V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The 50  $\mu$ s SB curve is beyond the thermal limits of this part. However, the parts will survive a transient that remains within these SB limits without failing.

... specifically designed for use in CRT deflection circuits.

- Collector-Emitter Voltage VCEX = 1500 Volts
- Glassivated Base-Collector Junction
- Forward Bias Safe Operating Area @ 50 μs = 20 A, 300 V
- Switching Times with Inductive Loads t<sub>f</sub> = 0.5 μs (Typ) @ I<sub>C</sub> = 3.0 A

4 AMPERE

NPN SILICON POWER TRANSISTOR

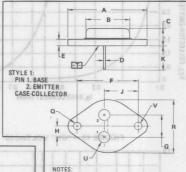
> 1500 VOLTS 100 WATTS

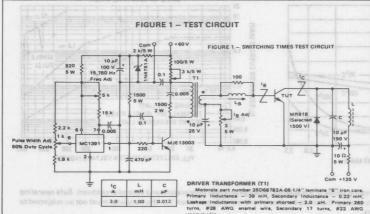
MAXIMUM RATINGS			
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	750	Vdc
Collector-Emitter Voltage	VCEX	1500	Vdc
Emitter-Base Voltage	VEBO	5.0	Vdc
Collector-Current — Continuous	I <sub>C</sub>	4.0	Adc
Base Current — Continuous	IB	3.0	Adc
Emitter Current - Continuous	IE a.t	7.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	100	Watts
T <sub>C</sub> = 100°C Derate above 25°C	9.5	40 0.8	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stq</sub>	-65 to +150	°С

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rajc	1.25	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C







4. DIMENSIONS AND TOLERANCES PER ANSIY14.5, 1973.

| MILLIMETERS | INCHES | DIM MIN MAX | MIN MA

♦ 0.13 (0.005) M T VM QM

1. DIMENSIONS Q AND V ARE DATUMS.
2. T. IS SEATING PLANE AND DATUM.

FOR LEADS:



#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Sustaining Voltage (IC = 50 mAdc, IB = 0)	VCEO(sus)	750		(27-0)	Vdc
Collector Cutoff Current (VCE = 1500 Vdc, VBE = 0)	CES	-		1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	IEBO	NOIT	BIABUI	1.0	mAdc
ON CHARACTERISTICS (1)					
Collector-Emitter Saturation Voltage (IC = 3.0 Adc, IB = 1.2 Adc)	VCE(sat)	n la <del>r</del> ge si	d for use	5.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 1.2 Adc)	V <sub>BE(sat)</sub>	-	-	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased	Is/b	nnar -	See Figure	5	sotto-7
DYNAMIC CHARACTERISTICS		A	20		
Current-Gain — Bandwidth Product ( $I_C = 0.1 \text{ Adc}$ , $V_{CE} = 5.0 \text{ Vdc}$ , $f_{test} = 1.0 \text{ MHz}$ )	fT	- no	itomul <sup>4</sup> iotos	ated Base-Coll	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	C <sub>ob</sub>	/ 00F,A	90 2 = 24 03 €	perating Area (	pF
SWITCHING CHARACTERISTICS					
Fall Time (I <sub>C</sub> = 3.0 Adc, I <sub>B1</sub> = 1.2 Adc, L <sub>B</sub> = 8.0 μH, See Figure 1)	tf	- 2020.	0.5	10 To Top	μѕ
	-				

5.0

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.

#### FIGURE 2 - DC CURRENT GAIN 20 VCE = 5 V TJ = 100°C 15 10 DC CURRENT 5.0

IC. COLLECTOR CURRENT (AMP)

1.0

0.2 0.3 0.5

0.05 0.1

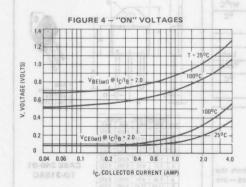


FIGURE 3 - COLLECTOR SATURATION REGION

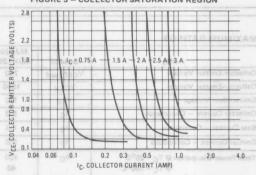


FIGURE 5 - MAXIMUM FORWARD BIAS



NOTE:
There are two limitations on the power handling ability of a transistor: average junction tempera-

There are two diministrations of the power harming during of a dialistic average joint on temperature and second breakdown. Safe operating area couves indicate  $E_{\rm c} = V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The 50  $\mu$ s and 1 ms curves are beyond the thermal limits of this part. However, the parts will survive a transient that remains within these S8 limits without failing.

3-945



### Designers Data Sheet

#### HORIZONTAL DEFLECTION TRANSISTOR

... specifically designed for use in large screen color deflection circuits.

- Collector-Emitter Voltage VCEX = 1500 Vdc
- Glassivated Base-Collector Junction
- Safe Operating Area @ 50 μs = 20 A, 400 V
- Switching Times with Inductive Loads —
   t<sub>f</sub> = 0.4 μs (Typ) @ I<sub>C</sub> = 4.5 A

#### MAXIMUM RATINGS

Rating 25 AS A A CLIFF	Symbol	MJ12004 MJH12004	Unit
Collector-Emitter Voltage	VCEO(sus)	750	Vdc
Collector-Emitter Voltage	VCEX	1500	Vdc
Emitter Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous	1 <sub>C</sub>	5.0	Adc
Base Current — Continuous	IB	4.0	Adc
Emitter Current — Continuous	I <sub>E</sub>	9.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD NO.	100 40 0.8	Watts W/°C
Operating and Storage Junction Temperature Range		-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.25	°C/W
Maximum Lead Temperature for Soldering	TL	275	°C
Purposes: 1/8" from Case for 5 Seconds			

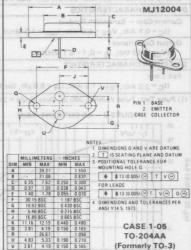
#### Designer's Data for "Worst Case" Conditions

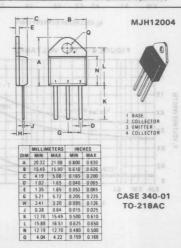
The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

#### 5.0 AMPERE

# NPN SILICON POWER TRANSISTORS

1500 VOLTS

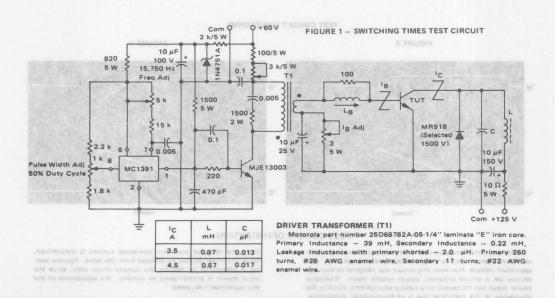




FLECTRICAL	CHARACTERISTICS	(To = 250 unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)	642 TO 962	nz en) gnin	OTHERS TO I	danuno atp	ву пож,
Collector-Emitter Sustaining Voltage (IC = 50 mAdc, IB = 0)	VCEO(sus)	750	eally angles	e current o seftection d	Vdc
Collector Cutoff Current (VCE = 1500 Vdc, VBE = 0)	CES	is is account	ssured. Th	1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	1EBO	equisity the ican ican ican.	he end of	1.0	mAdc
ON CHARACTERISTICS (1)	Suipen et	ध्रात्म राष्ट्रात र	TOTAL DE	Ver 67-older new	Inemograd
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 1.8 Adc) (I <sub>C</sub> = 3.5 Adc, I <sub>B</sub> = 1.5 Adc)	VCE(sat)	cor is driver bose curr	tput transis	5.0 5.0	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 4.5 Adc, I <sub>B</sub> = 1.8 Adc) (I <sub>C</sub> = 3.5 Adc, I <sub>B</sub> = 1.5 Adc)	V <sub>BE</sub> (sat)	m off, bearing	collector to	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased	Is/b	e le cising ve	See Fi	gure 14	on mode, s
DYNAMIC CHARACTERISTICS	nel month	- Looner to	nothin aged	adr wats or	Singuia oss
Current-Gain — Bandwidth Product (I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1 MHz)	tion in <b>T</b> his	anidimuser	xcess <b>4</b> corries	s allowing a	MHz
Output Gepacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	Cob	inign <del>ie</del> snot sonis isna	125 21	the mont Le	Cadonico en
SWITCHING CHARACTERISTICS	(west is a	and bns .rs	Luant) sale	deinay triette	werst impo
Fall Time T <sub>C</sub> = 25°C (I <sub>C</sub> = 4.5 Adc, I <sub>B1</sub> = 1.8 Adc, T <sub>C</sub> = 100°C L <sub>R</sub> = 8.0 μH, See Figure 1)	Lg, sighter Lg, sighter land the land land land land land land land land	function of intro-existri- extrad is to	0.4	dition, for A more in	esired cor
(1) Pulsa Tast: Pulsa Width < 200 us Duty Cycle = 2%	mwanie se e	1 to souley	Yo spines a 1	ersus to a To	v noissoissi

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.

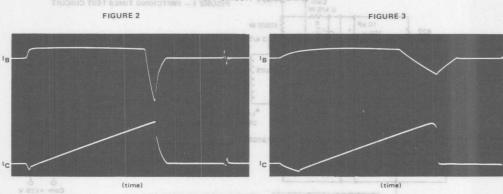


If the base of the output transistor is driven by a very low impedance source, the turn-off base current will reverse very quickly as shown in Figure 2. This results in rapid, but only partial, collector turn-off, because excess carriers become trapped in the high resistivity collector and the transistor is still conductive. This is a high dissipation mode, since the collector voltage is rising very rapidly. The problem is overcome by adding inductance to the base circuit to slow the base current reversal as shown in Figure 3, thus allowing excess carrier recombination in the collector to occur while the base current is still flowing.

Choosing the right  $L_B$  is usually done empirically, since the equivalent circuit is complex, and since there are several important variables ( $I_{CM}$ ,  $I_{B1}$ , and  $h_{FE}$  at  $I_{CM}$ ). One method is to plot fall time as a function of  $L_B$ , at the desired conditions, for several devices within the  $h_{FE}$  specification. A more informative method is to plot power dissipation versus  $I_{B1}$  for a range of values of  $L_B$  as shown

in Figures 4 and 5. This shows the parameter that really matters, dissipation, whether caused by switching or by saturation. The negative slope of these curves at the left (low IR1) is caused by saturation losses. The positive slope portion at higher IB1, and low values of LB is due to switching losses as described above. Note that for very low LB a very narrow optimum is obtained. This occurs when IB1 hFE = ICM, and therefore would be acceptable only for the "typical" device with constant ICM. As LB is increased, the curves become broader and flatter above the IB1 hFE = ICM point as the turn-off "tails" are brought under control. Eventually, if LB is raised too far, the dissipation all across the curve will rise, due to poor initiation of switching rather than tailing. Plotting this type of curve family for devices of different her, essentially moves the curves to the left or right according to the relation IB1 hFF = constant. It then becomes obvious that, for a specified I<sub>CM</sub>, an L<sub>B</sub> can be chosen which will give low dissipation over a range of hFE and/or IB1. The only remaining decision is to pick IB1 high enough to accommodate the lowest hee part specified. Figure 8 gives values recommended for LB and IB1 for this device over a wide range of I<sub>CM</sub>. These values were chosen from a large number of curves like Figure 4 and Figure 5. Neither LB nor IB1 are absolutely critical, as can be seen from the examples shown, and values of Figure 8 are provided for guidance only.

#### TEST CIRCUIT WAVEFORMS



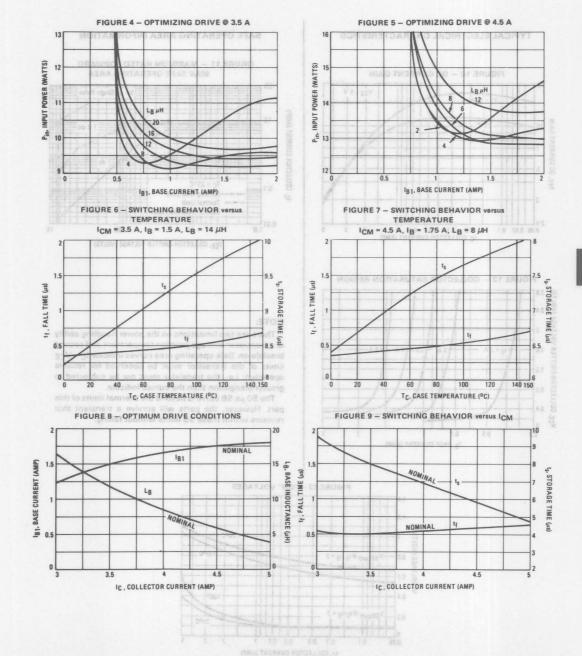
The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance.

Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

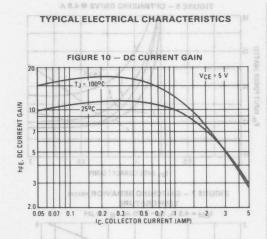
3

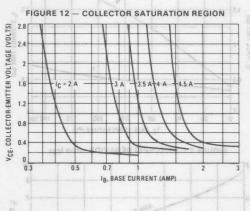
TEST CIRCUIT OPTIMIZATION



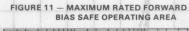


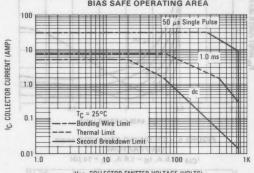






#### FIGURE 4 - OPTIMIZING DRIVE 9 3.5 A SAFE OPERATING AREA INFORMATION



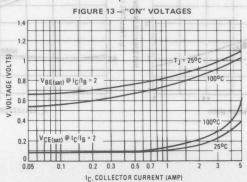


VCE. COLLECTOR-EMITTER VOLTAGE (VOLTS)

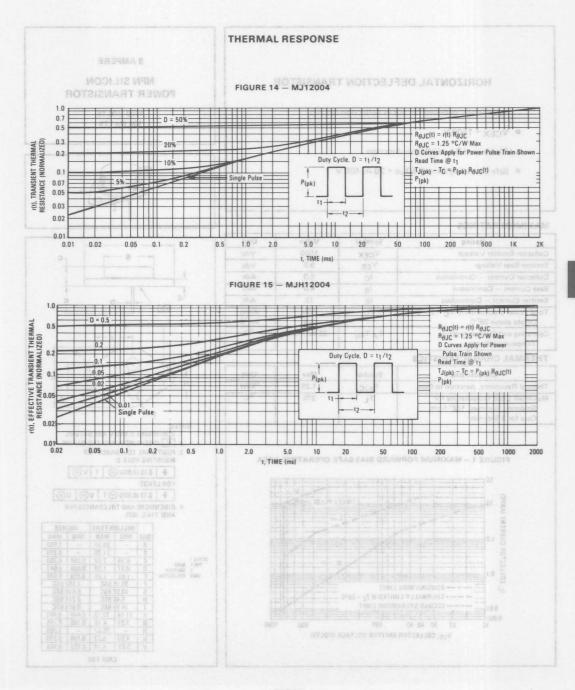
#### NOTE:

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The 50  $\mu$ s SB curve is beyond the thermal limits of this part. However, the parts will survive a transient that remains within these SB limits without failing.







#### HORIZONTAL DEFLECTION TRANSISTOR

. . . specifically designed for use in deflection circuits.

- VCEX = 1500 V
- Glassivated Base-Collector Junction
- Safe Operating Area @ 50 μs = 20 A, 400 V

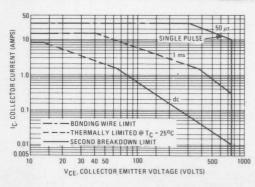
#### **MAXIMUM RATINGS**

Rating Man	Symbol	Value	Unit
Collector-Emitter Voltage	VCEX	1500	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous	lc lc	8.0	Adc
Base Current — Continuous	IB	4.0	Adc
Emitter Current - Continuous	1 <sub>E</sub>	12	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	100 0.8	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to + 150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25	°C/W
Maximum Lead Temperature for	T <sub>1</sub>	275	ос
Soldering Purposes: 1/8" from	CT		
Case for 5 Seconds	- and - and -		19 1

#### FIGURE 1 - MAXIMUM FORWARD BIAS SAFE OPERATING AREA

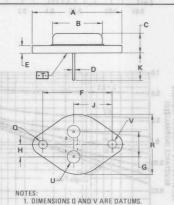


#### 8 AMPERE

#### NPN SILICON POWER TRANSISTOR

1500 VOLTS 100 WATTS





- 2. T. IS SEATING PLANE AND DATUM.
- 3. POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:

♦ 0.13 (0.005) M T V M

FOR LEADS:

♦ 0.13 (0.005) M T VM QM

4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

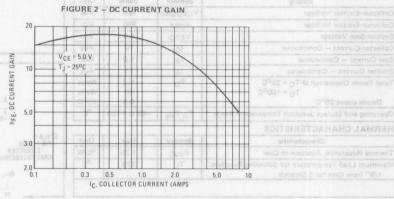
			MILLIN	METERS	INC	HES	
		DIM	MIN	MAX	MIN	MAX	
		Α	-	39.37	-	1.550	
		В	-	21.08	-	0.830	
STYLE 1	PIN 1. BASE 2. EMITTER	C	6.35	7.62	0.250	0.300	
		D	0.97	1.09	0.038	0.043	
CASE COLLECTOR	E	1.40	1.78	0.055	0.070		
		F	30.15 BSC		1.187 BSC		
		G	10.92	10.92 BSC		0.430 BSC	
		Н	5.48	BSC	0.215 BSC		
		J	16.89	BSC	0.665 BSC		
		K	11.18	12.19	0.440	0.480	
		0	3.81	4.19	0.150	0.165	
		R	-	26.67	-	1.050	
		U	4.83	5.33	0.190	0.210	
		٧	3.81	4.19	0.150	0.165	

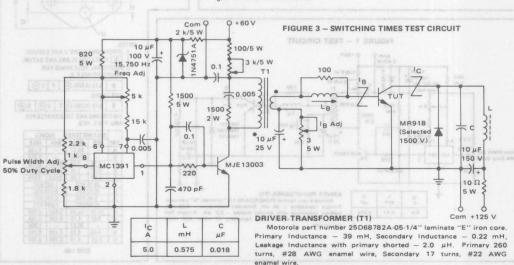
CASE 1-05

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (V <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	V <sub>CEOsus</sub> )	750	1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	-	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 1500 Vdc, V <sub>BE</sub> = 0)	ICES			0.25	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	<sup>1</sup> EBO	TRO ella	on not be one	0.1	mAdc
ON CHARACTERISTICS (1)					Provide the second
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)	VCE(sat)	Netion	Colhector Ja	5.0	Vdc
Base Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)	V <sub>BE(sat)</sub>	U @ earA	le O <sub>je</sub> erating with Tedas	s 2 aci 1.5 saw	ol Vdc
Second Breakdown Collector Current with Base Forward Biased	IS/b	-A 0.	tent (a)	See Fi	gure 1
SWITCHING CHARACTERISTICS					
Fall Time (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 1.0 Adc, L <sub>B</sub> = 8.0 μH)	tf	-	0.4	1.0	μs

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle =





#### . HORIZONTAL DEFLECTION TRANSISTOR

. . specifically designed for use in CRT deflection circuits.

- Collector-Emitter Voltage VCEX = 950 Volts
- Glassivated Base-Collector Junction
- Forward Bias Safe Operating Area @ 50 μs = 30 A, 300 V
- Switching Times with Inductive Loads  $t_f = 0.5 \,\mu s \,(Typ) @ I_C = 5.0 \,A$

10 AMPERE

NPN SILICON POWER TRANSISTOR

> 950 VOLTS 100 WATTS



#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	400	Vdc
Collector-Emitter Voltage	VCEX	950	Vdc
Emitter-Base Voltage	VEBO	5.0	Vdc
Collector-Current — Continuous	I <sub>C</sub>	10	Adc
Base Current — Continuous	1 <sub>B</sub>	5.0	Adc
Emitter Current — Continuous	IE	15	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	100 40 0.8	Watt Watt
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

₹1.8 k

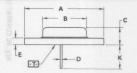
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.25	°C/W
Maximum Lead Temperature for Soldering Purposes:	T	275	°C
1/8" from Case for 5 Seconds	0.8		83 0

470 pF

0.57 0.039

5.0

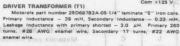
FIGURE 1 - TEST CIRCUIT



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

- DIMENSIONS Q AND V ARE DATUMS.
- 2. T. IS SEATING PLANE AND DATUM.
  3. POSITIONAL TOLERANCE FOR
- MOUNTING HOLE Q
  - ♦ 0.13 (0.005) M T V M
  - FOR LEADS:
- ♦ 0.13 (0.005) M T VM QM 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIN	MILLIMETERS		HES		
DIM	MIN	MAX	MIN	MAX		
Α	-	39.37	2 -	1.550		
В	-	21.08	-	0.830		
C	6.35	7.62	0.250	0.300		
D	0.97	1.09	0.038	0.043		
E	1.40	1.78	0.055	0.070		
F	30.15	BSC	1,187 BSC			
G	10.92	10.92 BSC		0,430 BSC		
H	5.46	BSC	0.215 BSC			
J	16.89	BSC	0.665 BSC			
K	11.18	12.19	0.440	0,480		
0	3.81	4.19	0.150	0.165		
R	-	26.67	-	1.050		
U	4.83	5.33	0.190	0.210		
W	3.81	4.19	0.150	0.165		



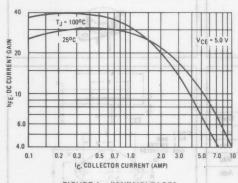
MR918 (Selected

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

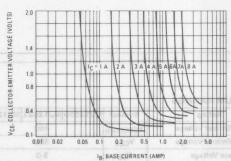
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	400	WEST SEC	-	Vdc
Collector Cutoff Current U.S. 0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.	ICES	-	-	1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	IEBO	-	-	1.0	mAdc
ON CHARACTERISTICS (1)					
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.2 Adc)	VCE(sat)	ANGE NP	MAGRARY MIGN TR	5.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.2 Adc)	V <sub>BE</sub> (sat)	-	-	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased	I <sub>S/b</sub>	desta susta	See Figure	5	id es do
DYNAMIC CHARACTERISTICS	horiunor si n	minwillah en			210000
Current-Gain — Bandwidth Product (I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	fT	-	6.0	samiT 110	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	Cob	Specified a	150	Storege and	num pF <sub>6</sub> M
WITCHING CHARACTERISTICS	0 005 010	on sauer	t organización	or monomine	Sunt place
Fall Time (I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 1.2 Adc, L <sub>B</sub> = 8.0 μH, See Figure 1)	tf	-	0.5	1.0	μѕ
AND IN THE DIE WITH COOK DIE OF LOOK					

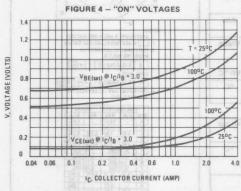
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.

#### FIGURE 2 - DC CURRENT GAIN

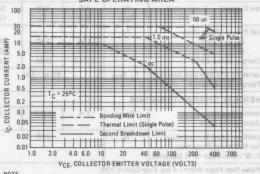


#### FIGURE 3 - COLLECTOR SATURATION REGION





#### FIGURE 5 - MAXIMUM FORWARD BIAS SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $|\xi| \sim V \xi \xi$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The 50 µs and 1 ms curves are beyond the thermal limits of this part. However, the parts will survive a transient that remains within these SB limits without failing.



## Designer's Data Sheet

#### HIGH PERFORMANCE NPN **DEFLECTION TRANSISTORS**

These transistors are designed for high resolution video systems, such as, high density graphic displays, data terminals, video scanners . . . wherever high frequency deflection is required.

- Fast Turn-Off Times
- Maximum Storage and Fall Times Specified at 100°C
- Operating Junction Temperature Range -65°C to +200°C
- High f<sub>T</sub> of 15 MHz

5.0, 8.0 and 15 AMPERE

#### **NPN SILICON** DEFLECTION **POWER TRANSISTORS**

850 VOLTS 125, 150 and 175 WATTS

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data. - representing device characteristics boundaries - are given to facilitate "worst case" design.



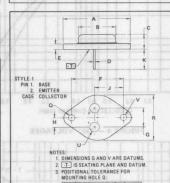
MANUALINA DATINICO

MAXIMUM RATINGS	A I A I				
Rating	Symbol	MJ12020	MJ12021	MJ12022	Unit
Collector-Emitter Voltage	VCEO(sus)		450	8	Vdc
Collector-Emitter Voltage	VCEV	1.0 80.0	850		Vdc
Emitter Base Voltage	VEB	gi.	6.0		Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	5.0	8.0 16	15 20	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	4.0 8.0	6.0	10 15	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25°C  @ T <sub>C</sub> = 100°C  Derate above 25°C	PD	125 71.5 0.714	150 85.5 0.86	175 100 1.0	Watts
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>		-65 to +200	2	°C

THERMAL	CHARACT	ERISTICS
---------	---------	----------

Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.4	1.17	1.0	°C/W
Maximum Lead Temperature	TL book	7	275	10	°C
for Soldering Purposes: 1/8" from Case for 5 Seconds	10 (15	H BE BE			2.5

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



♦ 0.13 (0.005) W T V W

FOR LEADS: ♦ 0.13 (0.005) (W) T V(W) Q(W) DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

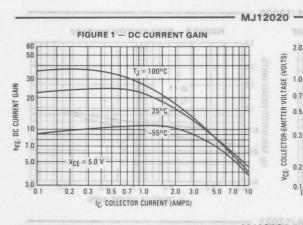
	MILLIN	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-1	1.550	
В	-	21,08	-	0.830	
C	6.35	7,62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15 BSC		1.187 BSC		
G	10.97	BSC	0.430 BSC		
Н	5.46	BSC	0.215 BSC		
J	16.89 BSC		0.66	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.151	0.165	
R	-	26.67	-	1,050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.151	0.165	

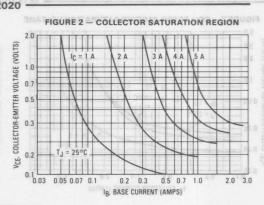
**CASE 1-05** TO-204AA (TO-3)

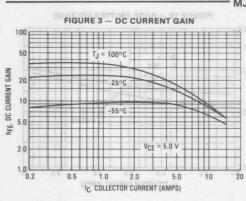
Characteristic mid		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)				isrics	CHARACTE	WITCHING
Collector-Emitter Sustaining Voltage (Table 1) (I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)	020	VCEO(sus)	450	evir@ bos	tohino, Clam	Vdc
Collector Cutoff Current (VCEV = 850 Vdc, VBE(off) = 1.5 Vdc) (VCEV = 850 Vdc, VBE(off) = 1.5 Vdc, TC = 100°C	p <sup>1</sup>	ICEV TJ = 26°	,08A,0,0 08) = 4.0 V	366	0.25	em mAdc emiT ile
Collector Cutoff Current (V <sub>CE</sub> = 850 Vdc, R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	1 3	ICER	t aldot as	cle € 2%} S	2.5 viu 2.5	mAdc
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0)	l u	IEBO	SOTIBIL	USMI SESS I	1.0	mAdc
SECOND BREAKDOWN			Sidal end I	HILL # 2 - 92 ,	day au - gr	30A 0.5 = 31)
Second Breakdown Collector Current with Base Fo	IS/b	See F	igures 19, 2	1 or 23		
Turn-Off SOA with Base Reverse Biased	RBSOA	See Figures 20, 22 or 24			MAG BAIRWING	
ON CHARACTERISTICS (1)	:	TJ=25°C		FO Vale: Vac		amil agaror
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc)	MJ12020 MJ12021 MJ12022	VCE(sat)	t uidal or	Vidth = 8.0 g de ≤ 2%) 8	Pulse	omi Vdcstoi emiT lle w2 evizoubi
Base Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc)	MJ12020 MJ12021 MJ12022	VBE(sat)	See <u>Table</u>	Ng 50° 28J	0 1.5 el 1.5 1.5	Vdc 1
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 5.0 Vdc) (I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 5.0 Vdc)	MJ12020 MJ12021 MJ12022	HE TJ = 25°	5.0 5.0 5.0	Adc_lg = 2. 120 vdc, Vg Wdd+= 8.0	= 00V- [	torage Time
DYNAMIC CHARACTERISTICS	N I	an Li	7 eldeT es	ata < 2%) Sr	Duty Cy	emil lie
Current Gain Bandwidth Product (I <sub>C</sub> = 0.3 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz) (I <sub>C</sub> = 1.3 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	MJ12020 MJ12021 MJ12022	fT	15 15 15	-	iching, Serie Ig = <del>2</del> 0 Ade	amiTime
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 kHz)	MJ12020 MJ12021 MJ12022	C <sub>ob</sub>	=	Ξ	200 350 400	pF

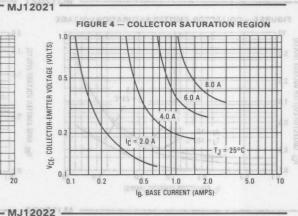
Unit	Characteristic	Mila	Symbo	Symbol	Min	Charqy Teriaria	Max	Unit
SWITCHING C	HARACTERISTICS					(1)	степівтісі	FF CHARA
Vdc		450	MJ120	20	(Tol	dsT) agatleV ga	itter Sustaini	ollector-Emi
Inductive Swite	ching, Clamped Drive		10/030				(0 = g1 ,A)	(IC = 100 m
Storage Time	(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.6 Adc, V <sub>CC</sub> = 40 Vdc, VBE(off) = 4.0 Vdc, Pulse Width = 8.0 μs, Duty Cycle ≤ 2%) See Table 1		T <sub>J</sub> = 25°C	ts	_	440	1200	ns
Fall Time					(39 <u>65</u> ) -	130	300	(ACEA = 88)
Storage Time			T <sub>J</sub> = 100°C	ts	19001	550	1500	98 - A32A)
Fall Time				tf		200	500	ollector Cut
Inductive Swite	ching, Series Base Induct	ance				111111111111111111111111111111111111111	200	low 2 sattim
Fall Time (I <sub>C</sub> = 3.0 Adc,	Time C = 3.0 Adc, lg = 0.6 Adc, Lg = 24 μH) See Table 2			tf	_	175		0 8 ns <sub>(3</sub> V)
			MJ120	21			HYOUNAN	No QHOUS
Inductive Swite	ching, Clamped Drive	452	4/-9	heza R hassa	Hase For	diiw mersi 1 vol	nelta3 awch	scood Bresi
Storage Time	(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc, V <sub>CC</sub> = 60 Vdc, V <sub>BE(off)</sub> = 4.0 Vdc, Pulse Width = 8.0		T <sub>J</sub> = 25°C	ts		550	1200	on character and officer and the character and t
Fall Time				t <sub>f</sub>		100	300	
Storage Time			T <sub>J</sub> = 100°C	ts		750	1600	
Fall Time				tf	_	180	500	
Inductive Swite	MJ12021		(10)	t lg = 2.0 Ad	(ig = 5.0 Ad			
Fall Time (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc, L <sub>B</sub> = 24 µH) See Table 2				t <sub>f</sub>	-	300	Seturation V c. la = 0.6 Az	nothins see
	1.6	-	MJ120	1			oA 0.1 = gl.o	
Inductive Switz	ching, Clamped Drive			N.112022			hà 0.5 - gl .:	(le=10 hts
Storage Time	(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc, V <sub>CC</sub> = 120 Vdc, V <sub>BE(off)</sub> = 4.0 Vdc, Pulse Width = 8.0 µs, Duty Cycle ≤ 2%) See Table 1		T <sub>J</sub> = 25°C			820	1800	C Current G
Fall Time				tf LAA		100	300	(IC = 8.0 Ac
Storage Time				ts		1100	2500	bA 81 = pt)
Fall Time			T <sub>J</sub> = 100°C	tf	_	130	400	YNAMIC O
Inductive Swite	ching, Series Base Induct	tance	71			to-bar	9 dtbiwbas8	
Fall Time — - 81				MJ12ff20	- 1	350	o, Vog= 10 V	A Ens of
(I <sub>C</sub> = 10 Adc,	B = 2.0 Adc, L <sub>B</sub> = 24 μH) S	See Table 2		MJ12021		(dc, (= 1.0 Mile	1 10 10 10 10 10 10 10 10 10 10 10 10 10	(1C = 1:0 Ad
				MJ12020 MJ12021		utput Capacitance (Vog = 10 Vdc, tg = 0, t = 1,0 xdHs)		

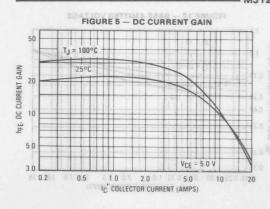
#### TYPICAL ELECTRICAL CHARACTERISTICS

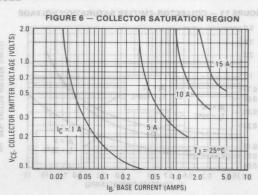




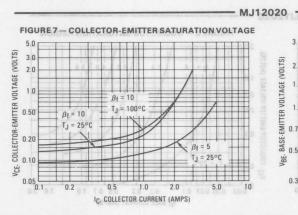


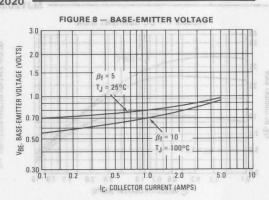






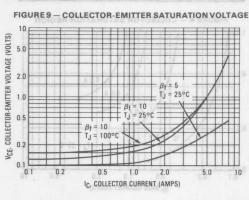
#### TYPICAL ELECTRICAL CHARACTERISTICS





- MJ12021 -





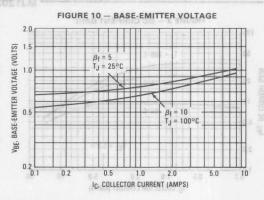
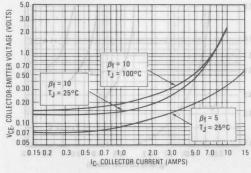
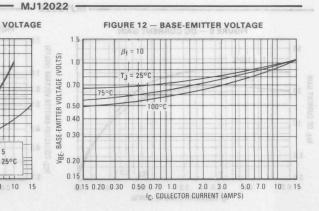


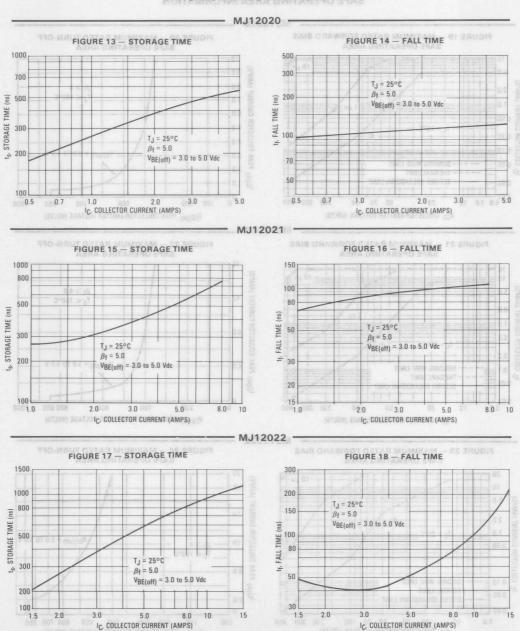
FIGURE 11 - COLLECTOR-EMITTER SATURATION VOLTAGE



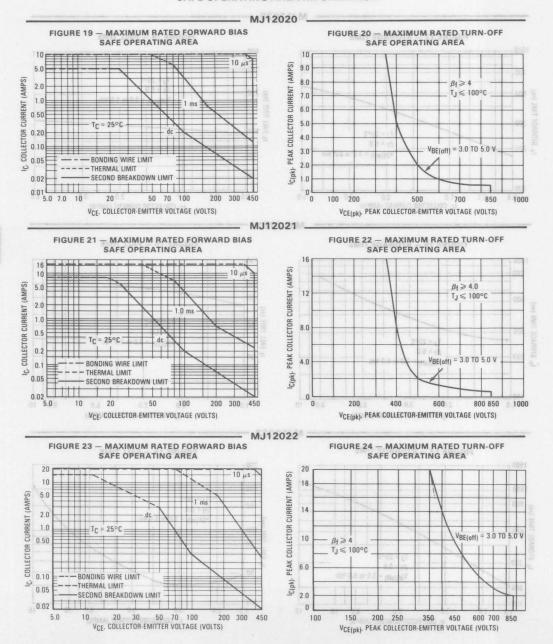


# 3

#### TYPICAL DYNAMIC CHARACTERISTICS



#### SAFE OPERATING AREA INFORMATION



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

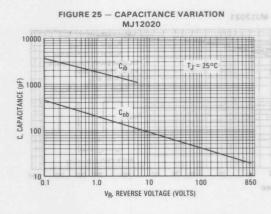
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

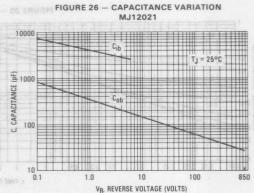
The data of Figures 19, 21 and 23 are based on  $T_C=25^{\circ}\text{C}; T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 19, 21 and 23 may be found at any case temperature by using the appropriate curve on Figure 28.

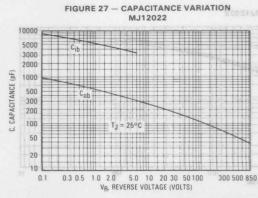
TJ(pk) may be calculated from the data in Figures 29, 30 or 31. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

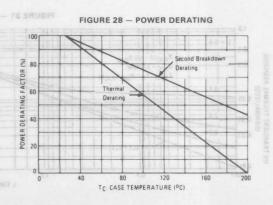
#### TURN-OFF

In deflection circuits, high voltage and high current normally do not occur simultaneously during turn-off with the base-emitter reverse biased. The safe level of operating these devices is specified as the Turn-Off Safe Operating Area, and represents the area the lead line may traverse during reverse biased turn off. For reliable operation, all abnormal operating conditions should be checked for operation within this area.

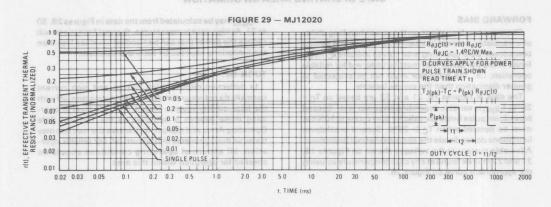


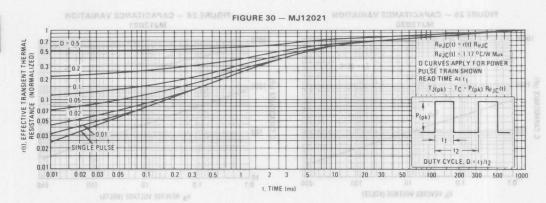


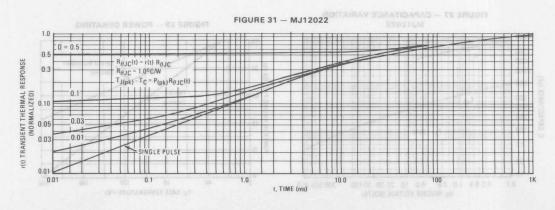




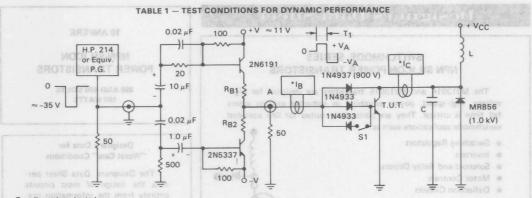
#### THERMAL RESPONSE







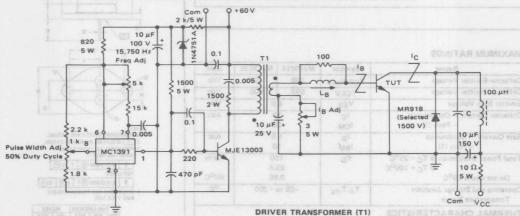




T<sub>1</sub> adjusted to obtain IC(pk) -VA adjusted to obtain VBE(off)

V(BR)CEO	Inductive Switching, Clamped Drive			Turn-Off SOA			
L = 10 mH	MJ12020	MJ12021	MJ12022	MJ12020	MJ12021	MJ12022	
R <sub>B2</sub> = ∞ V <sub>CC</sub> = 20 Vdc S1 — Open *Tektronix P-6042 or Equivalent	C = 0.003 μF V <sub>CC</sub> = 40 Vdc	C = 0.020 μF V <sub>CC</sub> = 60 Vdc	C = 0.036 μF V <sub>CC</sub> = 120 Vdc	C = 0.003 μF V <sub>CC</sub> = 20 Vdc	C = 0.020 μF V <sub>CC</sub> = 35 Vdc	C = 0.037 μF V <sub>CC</sub> = 55 Vdc	
	L = 100 µH, S1 — Closed  R <sub>B2</sub> = 0, R <sub>B1</sub> selected for required I <sub>B1</sub> Scope — Tektronix 7403 or Equivalent			L = 100 µH  RB2 = 0, RB1 selected for required lB1  S1 — Closed			

#### TABLE 2 - TEST CIRCUIT FOR INDUCTIVE SWITCHING WITH BASE INDUCTANCE



Device	VCC (Volts)	IC(pk) (Amp)	C (μF)
MJ12020	20	3.0	0.003
MJ12021	35	5.0	0.;020
MJ12022	55	10	0.036

Motorola part number 25D68782A-05-1/4" laminate "E" iron core. Primary Inductance - 39 mH, Secondary Inductance - 0.22 mH, Leakage Inductance with primary shorted  $-2.0~\mu\text{H}$ . Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.



## Designers Data Sheet

#### SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJ13014 and MJ13015 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn - Off Times:

60 ns Inductive Fall Time @ 25°C (Typ) 120 ns Inductive Crossover Time @ 25°C (Typ) 800 ns Inductive Storage Time @ 25°C (Typ)

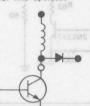
Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages

Leakage Currents



#### MAXIMUM RATINGS

Rating	Symbol	MJ13014	MJ13015	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	Vdc
Collector-Emitter Voltage	VCEV	550	600	Vdc
Emitter Base Voltage	VEB	6	6.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>CM</sub>	1 70 2	10	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		5.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	8	50 5.5 .86	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 t	o +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

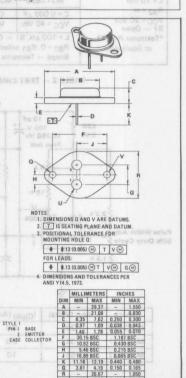
#### 10 AMPERE

#### NPN SILICON **POWER TRANSISTORS**

350 AND 400 VOLTS 150 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case"

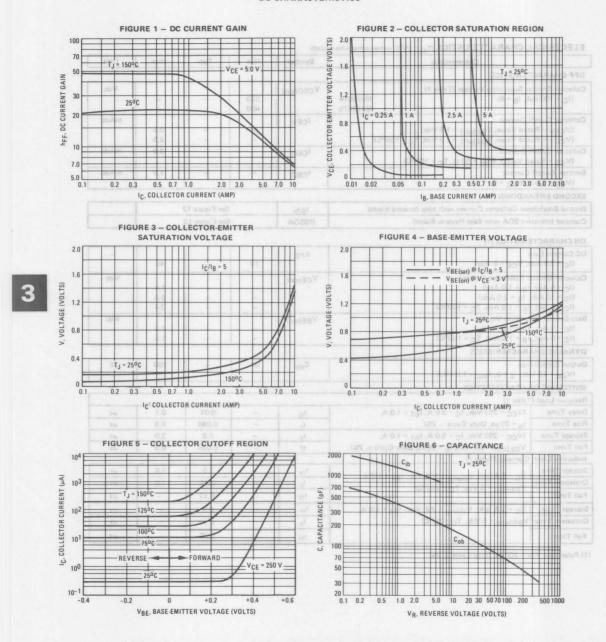


(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

## DC CHARACTERISTICS

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	E DIT	4 000 3			
Collector-Emitter Sustaining Voltage (Table 1)  (IC = 100 mA, IB = 0)  MJ13015  MJ13015	VCEO(sus)	350 400	KE		Vdc
Collector Cutoff Current $(V_{CEV} = Rated \ Value, V_{BE(off)} = 1.5 \ Vdc)$ $(V_{CEV} = Rated \ Value, V_{BE(off)} = 1.5 \ Vdc, T_C = 150^{\circ}C)$	ICEV	1	Ī	0.5 2.5	mAdo
Collector Cutoff Current (VCE = Rated VCEV, RBE = $50 \Omega$ , TC = $100^{\circ}$ C)	CER			3.0	mAdd
Emitter Cutoff Current (VEB = 6.0 Vdc, I <sub>C</sub> = 0)	IEBO	98 0.0	0.3 0.1	1.0	mAdd
SECOND BREAKDOWN THAN THE REAL STATE OF			CHREEKT (NMP	METHELTIEN GI	
Second Breakdown Collector Current with base forward biased	I <sub>S/b</sub>		See Figure 12		
Clamped Inductive SOA with Base Reverse Biased	RBSOA	20.00	See Figure 13	100.00	
ON CHARACTERISTICS (1) STTIMS SPAS - A SHUDPE			N ADTIVE	SATURATIO	
DC Current Gain (I <sub>C</sub> = 2.5 Adc, V <sub>CE</sub> = 5 Vdc)	hFE	12	हें - होतु।	40	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100°C)	VCE(sat)		-	1.4 5.0 2.4	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100°C)	VBE(sat)			1.5 1.5	Vdc
DYNAMIC CHARACTERISTICS		M			
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	C <sub>ob</sub>	50	+	350	pF
SWITCHING CHARACTERISTICS			0.0	THE AN	1
Resistive Load (Table 1)					
Delay Time (V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A, I <sub>B1</sub> = 1.0 A,	td	-	0.01	0.1	μѕ
Rise Time t <sub>D</sub> = 25 µs, Duty Cycle ~ 2%)	t <sub>r</sub>	_	0.085	0.5	μs
Storage Time (V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A, I <sub>B1</sub> = 1.0 A,	ts	-	0.8	2.0	μs
Fall Time $V_{BE(off)} = 5.0 \text{ Vdc}, t_p = 25 \mu s, \text{ Duty Cycle} \leq 2\%$	tf	NOTHER	0.095	0.5	μs
Inductive Load, Clamped (Table 1)	No.				
Storage Time (I <sub>C</sub> = 5 A(pk), V <sub>clamp</sub> = 250 Vdc, I <sub>R1</sub> = 1.0 A,	t <sub>sv</sub>	17/	1.5	3.5	μѕ
Crossover Time  VBE(off) = 5 Vdc, T <sub>C</sub> = 100°C)	t <sub>c</sub>		0.25	1.0	μς
Fall Time	ee tfi		0.12	_ 3/08	μs
Storage Time (I <sub>C</sub> = 5 A (pk), V <sub>clamp</sub> = 250 Vdc, I <sub>B1</sub> = 1.0 A,	t <sub>sv</sub>	1-2-	0.8	25-0-75	μs
Crossover Time VBE(off) = 5 Vdc, TC = 25°C)	t <sub>c</sub>	4	0.12		μs

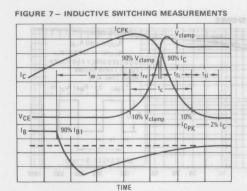
#### DC CHARACTERISTICS

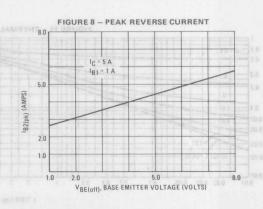


RBSOA AND INDUCTIVE SWITCHING RESISTIVE SWITCHING VCEO(sus) 250 μF 470 Ω \$47 \ 2 W 115 V 330 Ω CONDITIONS IB1 R2 0 2 -02 IB1 adjusted to obtain the forced her desired 5 W TURN OFF TIME 50 Ωξ \$100 Ω PW Varied to Attain Use inductive switching driver as the input to the resistive test circuit. 430 Ω All Diodes - 1N4934 39 Ω All NPN - MJE200 250 μF All PNP - MJE210 Adjust R1 to obtain IB1 For switching and RB<sub>SOA</sub>, R2 = 0 For BVCEO(sus), R2 = 00 L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V  $L_{coil}$  = 80 mH  $V_{CC}$  = 10 V  $R_{coil}$  = 0.7  $\Omega$ V<sub>CC</sub> = 250 V R<sub>L</sub> = 50 Ω V<sub>clamp</sub> = 250 V R<sub>B</sub> adjusted to attain desired I<sub>B1</sub> Pulse Width = 10 μs INDUCTIVE TEST CIRCUIT **OUTPUT WAVEFORMS** RESISTIVE TEST CIRCUIT Obtain IC CIRCUITS RL ₹ vcc Vcc 1N4937 Lcoil (ICpk) TEST Detailed Conditions Test Equipment Scope - Tektronix 475 or Equivalent

Time

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE





#### SWITCHING TIMES NOTE

times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>c</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

In resistive switching circuits, rise, fall, and storage is shown in Figure 7 to aid in the visual identity of these

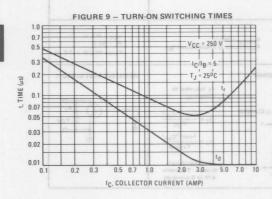
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

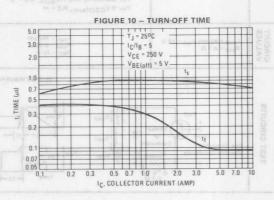
 $\begin{array}{c} P_{SWT} = 1/2~V_{CC}I_{C}(t_{c})f \\ \text{In general, } t_{rv} + t_{fi} \cong t_{c}.~\text{However, at lower test currents} \end{array}$ this relationship may not be valid.

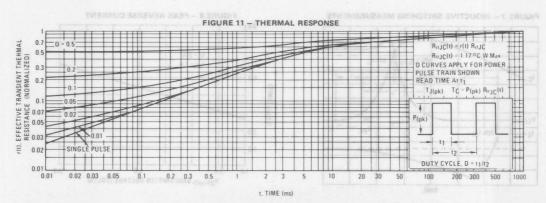
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{C}$  and  $t_{SV}$ ) which are guaranteed at 100°C.

#### **RESISTIVE SWITCHING**



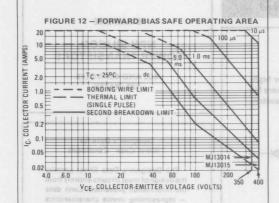




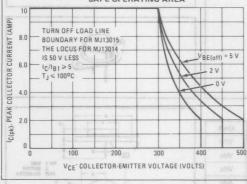




The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.



#### FIGURE 13 – REVERSE BIAS SWITCHING SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

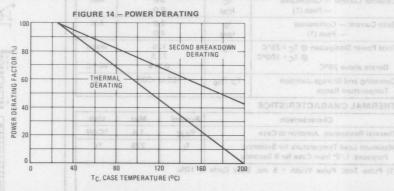
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

## REVERSE BIAS - of 63- sone 8 stute segment anits sego

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.





## Designer's Data Sheet

#### SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The MJ13070 and MJ13071 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters 1 9 1 9 1 9 1 9 1
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

100 ns Inductive Fall Time @ 25°C (Typ)

150 ns Inductive Crossover Time @ 25°C (Typ) 400 ns Inductive Storage Time @ 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads

Saturation Voltages proposed seems asked based

Leakage Currents



specified for these devices under the test conditions show

#### NPN SILICON POWER TRANSISTORS

400 AND 450 VOLTS 125 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries — are given to facilitate "worst case" design.



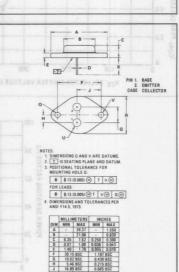
# MAXIMUM RATINGS OF A STITUTE OF THE STITUTE OF THE

Rating	Symbol	MJ13070	MJ13071	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	650	750	Vdc
Emitter Base Voltage	VEB	eu si eo a e	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>		.0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	ARIO 71	25 1.5 714	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.4	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

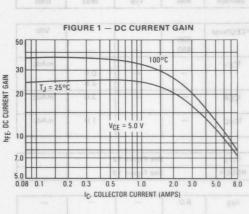
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

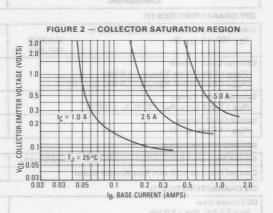


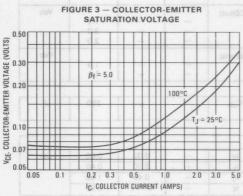
**CASE 1-05 TO-3 TYPE** 

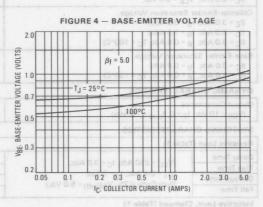
	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTE	RISTICS (1)	-			The Rule		
Collector-Emitter S	Sustaining Voltage (Table 1)	AGURE 2	VCEO(sus)	MIAD T	BARGO DO	- ranuar	Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0) MJ13070		020(303)	400	1 17:17	11-		
		MJ13071		450			
Collector Cutoff Cu		3	ICEV				mAdc
	alue, VBE(off) = 1.5 Vdc)	E1 2				0.5	
	alue, VBE(off) = 1.5 Vdc, TC =	100°C)		17/		2.5	11, = 259
Collector Cutoff Cu			CER	17	T	3.0	mAdc
	EV. R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	TU = 9		4		1.0	mAdc
(VEB = 6.0 Vdc, I			IEBO		V 0.8 = 3	1.0	made
SECOND BREAK		111111111111111111111111111111111111111	137				
	n Collector Current with Base	Forward Biased	I <sub>S/b</sub>		See Figure 1	2	
	SOA with Base Reverse Bias	100.00	RBSOA		See Figure 1		
ON CHARACTER	10 00 00 10 10	0.0 E00 S0.0	0.8 0.8	2.0 3.0	0.7	2 0.3 0.5	0 10 2
	131103 (1)		I h I	9.0	ALTERDILIT SAT	16 correct	
OC Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>C</sub>	e = 5.0 Vdc		hFE	8.0			
Collector-Emitter S			V <sub>CE(sat)</sub>	RETTIME	BUTTOR	0 - 8 SMUB	Vdc
(IC = 3.0 Adc, IB	= 0.6 Adc)		OL(30t)	_ 30	HONLYOUT		
(Ic = 5.0 Adc, IB	= 1.0 Adc)			17	HITTI	3.0	
	= 0.6 Adc, T <sub>C</sub> = 100°C)				HITH	2.0	
Base-Emitter Saturation Voltage (IC = 3.0 Adc, IB = 0.6 Adc)		VBE(sat)			1.5	Vdc	
	= 0.6 Adc, T <sub>C</sub> = 100°C)		INN		HILL	0.8-1.5	
DYNAMIC CHAR	ACTERISTICS	OTHER S	HA	V 1			
Output Capacitano	e	111111111111111111111111111111111111111	Cob			250	pF
	E = 0, f <sub>test</sub> = 1.0 kHz)		00	N			
SWITCHING CHA	RACTERISTICS	1441 8		1			-111-1-
Resistive Load (Ta	able 1)	111111111111111111111111111111111111111			HIM		
Delay Time		THE TENE	t <sub>d</sub>		0.03	0.05	μS
Rise Time	(V <sub>CC</sub> = 250 Adc, I <sub>C</sub> = 3.0 A	dc,	t <sub>r</sub>		0.10	0.40	
Storage Time	$l_{B1} = 0.4$ Adc, $t_p = 30 \mu s$ , Duty Cycle $\leq 2\%$ , $V_{BE(off)}$	5 0 Vdc)	ts	11.5	0.40	1.50	
Fall Time	Doty Cycle 42 W. VBE(OII)	0.0 vacy	tf	- (5.4)6	0.175	0.50	
Inductive Load, C	lamped (Table 1)						
Storage Time	*****		t <sub>sv</sub>	was a second	0.70	2.0	μS
Crossover Time	(I <sub>C(pk)</sub> = 3.0 A,	(T <sub>J</sub> = 100°C)	t <sub>C</sub>	00/8/1 <u>3</u> 1 10/	0.28	0.50	
Fall Time	I <sub>B1</sub> = 0.4 Adc,	THE PART OF THE PA	tfi	X-1	0.15	0.30	
Storage Time	VBE(off) = 5.0 Vdc,		t <sub>sv</sub>	17	0.40	+ 1	
Crossover Time Fall Time	VCE(pk) = 250 V)	(T <sub>J</sub> = 25°C)	t <sub>c</sub>	17-1	0.15	-	
			tfi	12	0.10	50001	
. 0// 1/1/10	300 μs, Duty Cycle ≤2%.			XX		30.851	
1) Pulse Test: PW - 3							
1) Pulse Test: PW - 3							
1) Pulse Test: PW - 3							
1) Pulse Test: PW - 3							
1) Pulse Test: PW - 3		C CVBVOLY					
1) Pulse Test: PW - 3	7, 28-0	00 1 00 D	V 025		DRAWRO -	1883 A3 1862 - 1	а
1) Pulse Test: PW - 3	998 (1	001	V 085		DAKWAD) -	3°65 2°65 2°65 3°65	IA
1) Pulse Test: PW - 3	2085 17	001	290 V		anavano I	3067 1803 A3 24100	A .

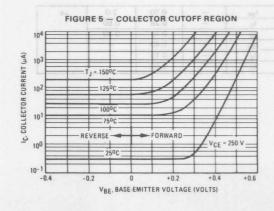
## TYPICAL ELECTRICAL CHARACTERISTICS CONTENSTO ANAMA JACKSTONIA

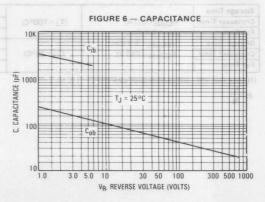








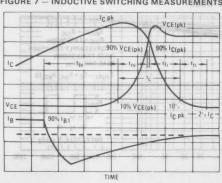




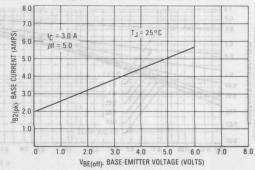
RESISTIVE SWITCHING RBSOA AND INDUCTIVE SWITCHING VCEO(sus) 100 ~~ H.P. 214 or Equiv. 2N6191 20 ¥ 10 µF ₹ RB1 20 CONDITIONS 大 0 02 uF I<sub>B1</sub> adjusted to obtain the forced hpE desired \$ 50 1.0 uF 2N5337 TURN OFF TIME ₹ 500 PW Varied to Attain Use inductive switching driver as the input to 100 the resistive test circuit. Adjust R1 to obtain IB1 For switching and RBSOA, R2 = 0 For BVCEO(sus), R2 = 0 CIRCUIT L<sub>coil</sub> 180 μH R<sub>coil</sub> - 0.05 Ω V<sub>CC</sub> + 20 V V<sub>CC</sub> = 250 V R<sub>E</sub> = 83 Ω Pulse Width = 10 μs Lcoil = 80 mH VCC = 10 V V<sub>clamp</sub> - 250 V R<sub>B</sub> adjusted to attain desired l<sub>B1</sub> R<sub>coil</sub> = 0.7 Ω INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to Obtain IC CIRCUITS F VC VCC Vcc 1N4937 -0 Lcoil (ICpk) t<sub>2</sub> ≈ V<sub>clamp</sub> TEST **Detailed Conditions** VCE = 0 R<sub>S</sub> = 0 0.1 Ω Test Equipment Scope - Tektronix Time 12-1 475 or Equivalent

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

#### FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS OF JAMASHT — IT FIGURE 8 — PEAK REVERSE CURRENT







## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these

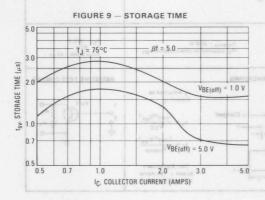
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

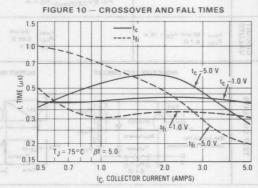
In general,  $t_{rv}$  +  $t_{fi}$   $\cong$   $t_{c}$ . However, at lower test currents this relationship may not be valid.

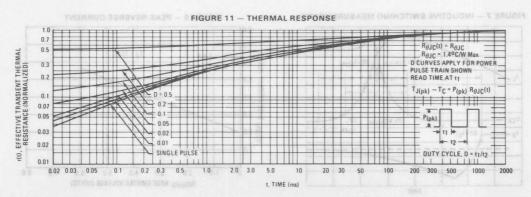
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING





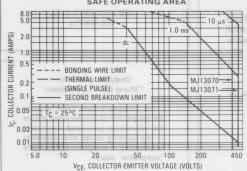




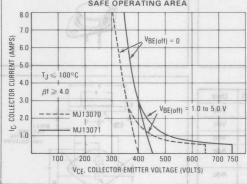


The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

#### FIGURE 12 - MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 13 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

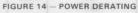
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

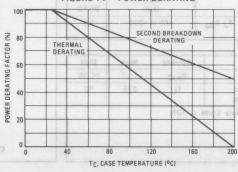
The data of Figure 12 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J</sub>(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS I evitoribel of the earth politically?

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.





## Designer's Data Sheet

#### SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The MJ13080 and MJ13081 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters \*\* of 23 byo ytub
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times

100 ns Inductive Fall Time @ 25°C (Typ)

150 ns Inductive Crossover Time @ 25°C (Typ) 400 ns Inductive Storage Time @ 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads | 3293 V38

Saturation Voltages doing about avitables no l

Leakage Currents



#### NPN SILICON **POWER TRANSISTORS**

**400 AND 450 VOLTS** 150 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.

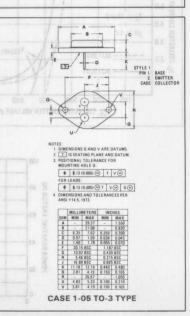


#### MAXIMUM RATINGS

leteves v.Rating Igmoode ad ne	Symbol	MJ13080	MJ13081	Unit
Collector-Emitter Voltage 39 gnique	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	650	750	Vdc
Emitter Base Voltage	VEB	8 exerce 8		Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	8.0		Adc
Base Current — Continuous — Peak (1)	I I R	3.0		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	150 85.5 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

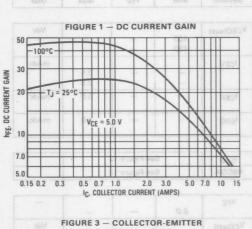
#### THERMAL CHARACTERISTICS

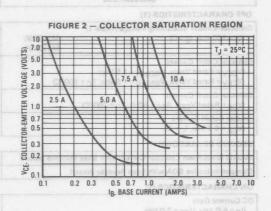
Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.17	°C/W	
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C	
(1) Pulse Test: Pulse Width = 5 ms, Duty Cyc	cle ≤ 10%.			

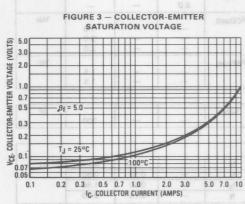


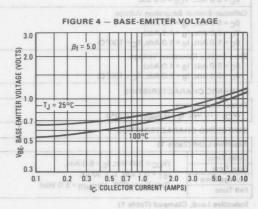
	Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTE	RISTICS (1)							
	Sustaining Voltage (Table 1)	390019	V <sub>CEO(sus)</sub>	WIAD THE	BC CURS	FIGURE 1 -	Vdc	
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0) MJ13080		CLO(3d3)	400	1 + 1				
3082 = 11		MJ13081		450			-100001-	
Collector Cutoff Cu	irrent	1000	ICEV		KII		mAdc	0.0
(VCEV = Rated V	alue, VBE(off) = 1.5 Vdc)	- OF W			+	0.5		
(VCEV = Rated V	alue, $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_{C} =$	100°C)	1111	1-1	1	2.5	-	_
Collector Cutoff Cu		VARS S	ICER	11/1/	1 + 1	3.0	mAdc	
	EV. $R_{BE} = 50 \Omega$ , $T_{C} = 100^{\circ}C$ )	And the second second		1				
Emitter Cutoff Cur			IEBO		+ 40	1.0	mAdc	
(V <sub>EB</sub> = 6.0 Vdc, I			1110				-	21
SECOND BREAK		E.0 g						
Second Breakdown	Collector Current with Base	e Forward Biased	IS/b	S	ee Figure 12	2		5.1
Clamped Inductive	SOA with Base Reverse Bia	sed	RBSOA	S	ee Figure 13	3		5.0
ON CHARACTER	ISTICS (1)							
DC Current Gain	Control State of the Control of the		hFE				_	
(I <sub>C</sub> = 5.0 Adc, V <sub>C</sub>	E = 3.0 Vdc			8.0	-	-		
Collector-Emitter S			VCE(sat).	ASTRMS-R	COLLECTO	- E SEUDP	Vdc	
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub>				_BDAT	ATION YOU	1.0		
(Ic = 8.0 Adc, IB				T		3.0		
	= 1.0 Adc, T <sub>C</sub> = 100°C)	4 1 1 1 1 1 1		1-1-1-	$+\Xi$	2.0	100	0.8
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)		VBE(sat)	1		1.5	Vdc		
	= 1.0 Adc, T <sub>C</sub> = 100°C)			-		1.5		
DYNAMIC CHAR			KHIT					0.5
Output Capacitano		D -1,= 26 °C	T c. 1			0.00	pF	a.J
	E = 0, f <sub>test</sub> = 1.0 kHz)		Cob			300	pr	
SWITCHING CHA	1 1 19-51 1 1 1	1100						200
	1 1 1 1 1 1 1 1 1 1	205		700		2030		5-4
Resistive Load (Ta	ible 1)					1 1 63 -	V	i
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 5.0 A	Adc,	td	1	0.025	0.05	μS	
Rise Time Storage Time	$I_{B1} = 0.7 \text{ Adc}, t_p = 30 \mu s,$		tr	2.0 2.0	0.10	1.50	0.1	
Fall Time	Duty Cycle ≤2%, VBE(off)	= 5.0 Vdc)	t <sub>S</sub>	_129/4A7	0.15	0.50	1.0	
Inductive Load, C	lamped (Table 1)		1 1		0.10	0.00		-
	lamped (Table T)		T . I		0.75	2.22		_
Storage Time Crossover Time	May 0 = 5 O A Terrora	(T <sub>.1</sub> = 100°C)	tsv	036.22077	0.75	0.40	μS	
Fall Time	(I <sub>C(pk)</sub> = 5.0 A, III III III III III III III III III	(1J = 100°C)	t <sub>C</sub>	1010	0.22	0.40		
Storage Time	V <sub>BE(off)</sub> = 5.0 Vdc,		t <sub>SV</sub>	BEK	0.40	0.33		
Crossover Time	V <sub>CE(pk)</sub> = 250 V)	(T <sub>J</sub> = 25°C)	t <sub>C</sub>	1-2-1	0.15			
Fall Time	OC(pk)	1.5	tfi	-	0.10			
1) Pulse Test: PW - 3	300 μs, Duty Cycle ≤2%.	1 - 1 - 1 oco (#	1 1	LXX	- P-	15070		
lo	27 5017 07010 QE/0.							
$\beta_f = \frac{1}{I_B}$		中山二 章						
						0,001		
		901 5						100
			-	-UR				
			The Villa of					

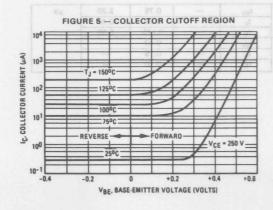
#### TYPICAL ELECTRICAL CHARACTERISTICS OF REMATO ANAMO JACHRICALIS

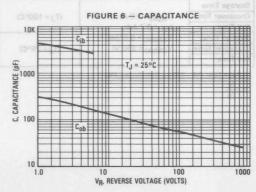








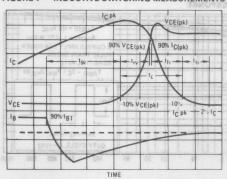




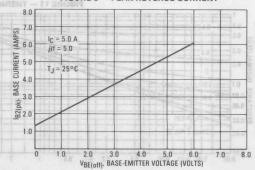
his of Tanger RBSOA AND INDUCTIVE SWITCHING VCEO(sus) RESISTIVE SWITCHING 0.02 µF Q+V = 11 V 100 -H.P. 214 or Equiv 2N6191 PG 20 0\_ ¥ 10 µF ₹RB1 O A 20 (2) CONDITIONS RB2 = 늘 木 0 02 µF \$ 50 ham 1.0 µF IB1 adjusted to obtain the forced 2N5337 he desired TURN OFF TIME \$ 500 Use inductive switching IC = 100 mAS 100 driver as the input to Adjust R1 to obtain I<sub>B1</sub> For switching and RB<sub>SOA</sub>, R2 = 0 For BVCEO(sus), R2 = 00 CIRCUIT L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V V<sub>CC</sub> = 250 V R<sub>L</sub> = 50 Ω Pulse Width = 30 μs L<sub>coil</sub> = 80 mH V<sub>CC</sub> = 10 V V<sub>clamp</sub> = 250 V R<sub>B</sub> adjusted to attain desired I<sub>B1</sub> R<sub>coil</sub> = 0.7 Ω OUTPUT WAVEFORMS INDUCTIVE TEST CIRCUIT RESISTIVE TEST CIRCUIT t<sub>1</sub> Adjusted to Obtain Ic CIRCUITS TUT Vcc Lcoil (ICpk) TEST ( V<sub>clamp</sub> VCE VCE Vclamp = 0 R<sub>S</sub> = 0 0.1 Ω 2 Test Equipment Scope - Tektronix 1-12-1 475 or Equivalent

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

## FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS



#### FIGURE 8 — PEAK REVERSE CURRENT



## SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

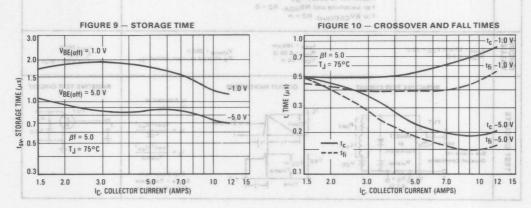
is shown in Figure 7 to aid in the visual identity of these

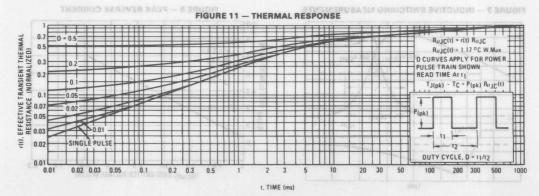
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $\begin{array}{c} P_{SWT} = 1/2 \; V_{CC} I_{C}(t_{c}) \, f \\ \text{In general, } t_{rv} + t_{fi} \cong t_{c}. \; \text{However, at lower test currents} \\ \text{this relationship may not be valid.} \end{array}$ 

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING

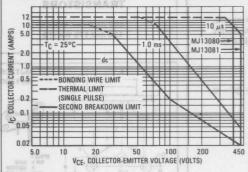




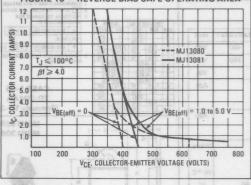
3-982

The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

#### FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 13 - REVERSE BIAS SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

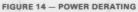
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

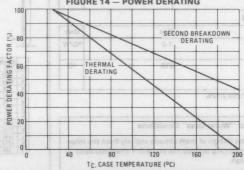
The data of Figure 12 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J</sub>(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.







## Designer's Data Sheet

#### will de gallbaset source SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS ndicate IC-VCE

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switch-mode applications The date of Figure 12 is based on To = 2:sup I to stab and

- Switching Regulators
- Inverters
  - Solenoid and Relay Drivers
  - Motor Controls Motor Control Control
- Deflection Circuits

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads — And JA 150 ns Inductive Fall Time (Typ)

Saturation Voltages and pasagani anoitatimal Leakage Currents

#### MAYIMUM PATINGS

MAXIMOM HATHIO	•					
Rating ons	Symbol	MJ13090	MJ13091	MJH13090	MJH13091	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	400	450	400	450	Vdc
Collector-Emitter Voltage	VCEV	650	750	650	750	Vdc
Emitter-Base Voltage	VEB	TOD SEST	6	3.0		Vdc
Collector Current  — Continuous  — Peak (1)	I <sub>C</sub> M		or bien memuo 1 s se dul	15 20 100		Adc
Base Current  — Continous  — Peak (1)	I <sub>B</sub>	shaping etc. The safe levit os Ro 10.2 Birs Safe Opera				
Total Device Dissipation  @ T <sub>C</sub> = 25°C  @ T <sub>C</sub> = 100°C  Derate above 25°C	P <sub>D</sub>	fied und fubjects fustassissis	ce is ne 00	lysb and 5	25 60 .0	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 t	о 200	-	o 150	°C

#### THERMAL CHARACTERISTICS

THEMMAL CHANAC	LINIOTICO				
Characteristic	Symbol	MAGGRAZUM	Max		Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	DWITARS	1.0	4/1	°C/W
Lead Temperature for Soldering Purposes, 1/8" from Case for 5 Seconds.	TL		275	JAMASHT QUITARSO	°C

(1) Pulse Test: Pulse Width ≤ 5.0 μs, Duty Cycle ≥10%.

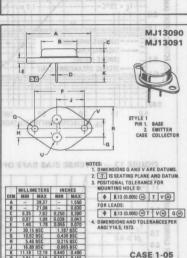
#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves - representing boundaries on device characteristics are given to facilitate "worst case" design.

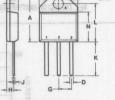
#### 15 AMPERE

#### **NPN SILICON** POWER **TRANSISTORS**

**400 AND 450 VOLTS** 125 and 175 WATTS



TO-204AA (Formerly TO-3) MJH13090 MJH13091



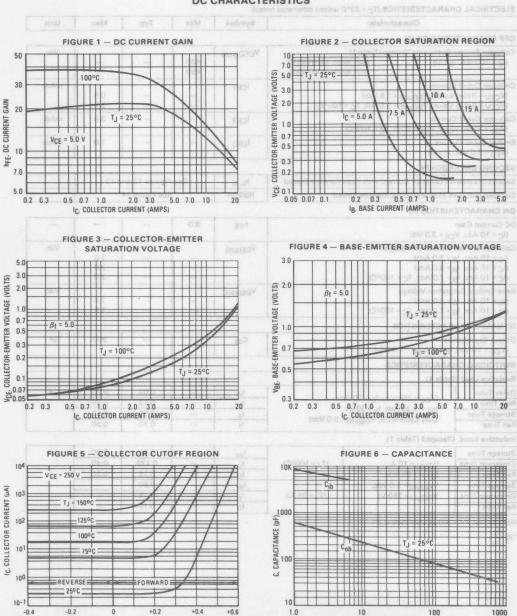
BASE COLLECTOR EMITTER COLLECTOR

Q 4.04 4.22 0.159 0.166

**CASE 340-01** TO-218AC

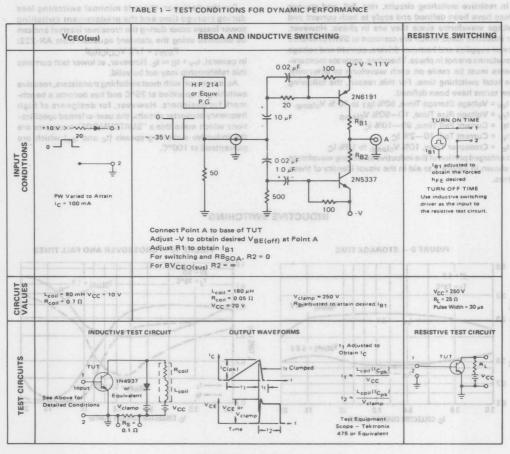
	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTE	RISTICS (1) POYDELICO -	e stations		MAG	THERRUD D	M _ P 7000	2012
Collector-Emitter Sustaining Voltage (Table 1)		VCEO(sus)	277			Vdc	
(Ic = 100 mA, Ig	= 0) MJ1309	0, MJH13090	020(000)	400	-		
	MJ1309	1, MJH13091		450		56001	777
Collector Cutoff C	urrent		ICEV		/	III	mAdo
	'alue, VBE(off) = 1.5 Vdc)			HH	- 1	0.5	
(VCEV = Rated V	falue, $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_{C} = 1$	00°C)		THA		2.5	-
Collector Cutoff C			ICER	JHH	- 2988	3.0	mAdo
(V <sub>CE</sub> = Rated V <sub>C</sub>	EV, R <sub>BE</sub> = 50 Ω, $T_C$ = 100°C)						
Emitter Cutoff Cur			IEBO	11	-	1.0	mAdd
(V <sub>EB</sub> = 6.0 Vdc,	IC = 0)	THIT 8	79				
SECOND BREAK	DOWN	20 8					
Second Breakdow	n Collector Current with Base	Forward Biased	ls/b	See	Figures 12 an	id 13	
Clamped Inductive	SOA with Base Reverse Biase	ed IA SOO SOO	RBSOA	00 00 0	See Figure 14	A+ + a	20 5
ON CHARACTER	RISTICS (1)				(SHERT (AMPS)	O ROTOBLIGG &	g)
DC Current Gain			hFE	8.0	_	_	_
(I <sub>C</sub> = 10 Adc, V <sub>C</sub>	E = 3.0 Vdc			0.0			
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc)		V <sub>CE(sat)</sub>	313	HON VOLTAL	SATURA	Vdc	
		OL(SUL)			1.0		
(IC = 15 Adc, IB	= 3.0 Adc)					3.0	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub>	= 2.0 Adc, T <sub>C</sub> = 100°C)					2.0	
Base-Emitter Satu	ration Voltage		V <sub>BE(sat)</sub>				Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub>				-		1.5	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub>	= 2.0 Adc, T <sub>C</sub> = 100°C)	35	Bigles			1.5	
DYNAMIC CHAP	ACTERISTICS						
Output Capacitano	e	1	Cob	<b>25-11</b>		350	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)				300	11=11		
SWITCHING CHA	ARACTERISTICS				D.		
Resistive Load (T	able 1)		land.	0.00	135		
Delay Time			td		0.03	0.05	μѕ
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 Ad		tr	01 01	0.13	0.50	
Storage Time	$I_{B1} = 1.25 \text{ Adc}, t_p = 30 \mu s,$		ts		0.55	2.50	3.0 61
Fall Time	Duty Cycle ≤2%, VBE(off) =	5.0 Vdc)	tf	_	0.10	0.50	1
Inductive Load, C	lamped (Table 1)				F11 A 73		
	HOURE & - CAPACITANCE		I t I	010 2 8 3 8	0.80	3.00	μS
Crossover Time	(I <sub>C(pk)</sub> = 10 A,	(T <sub>.1</sub> = 100°C)	t <sub>SV</sub>	LIGHT TO	0.175	0.40	μS
Fall Time	I <sub>B1</sub> = 1.25 Adc,	1.5 100 01	tfi	X-5-X	0.175	0.40	100
Storage Time	V <sub>BE(off)</sub> = 5.0 Vdc,	123 -1 1		TITTE	0.50	0.30	101-357
Crossover Time	V <sub>CE(pk)</sub> = 250 V)	(T <sub>.1</sub> = 25°C)	t <sub>sv</sub>		0.15		
Fall Time	*GE(DK) = 200 V/	(1) - 20 0)	tfi	1	0.10	Jene Jene	17

#### DC CHARACTERISTICS



VBE, BASE-EMITTER VOLTAGE (VOLTS)

VR. REVERSE VOLTAGE (VOLTS)



PIGURE 11 - THERMAL RESPONSE FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS FIGURE 8 — PEAK REVERSE CURRENT 10 IC pk VCE(pk) 9.0 IC = 10 A (8.0 7.0 7.0 -TJ = 25°C  $\beta f = 5.0$ 90% VCE(pk) 90% (C(pk) 0.6 0.8 0.9 0.9 0.9 BASE 4.0 VCE -10% VCE(pk) 10% 82(pk) 2.0 - 2% IC IC Pk -90% 181 18---1.0 3.0 4.0 1.0 2.0 5.0 6.0 7.0 VBE(off). BASE-EMITTER VOLTAGE (VOLTS) TIME

#### **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10 % Vclamp

trv = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90—10% IC tti = Current Tail, 10—2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

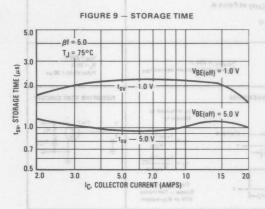
PSWT = 1/2 VCCIC(tc)f

In general,  $t_{\Gamma V} + t_{fi} \simeq t_C$ . However, at lower test currents this relationship may not be valid.

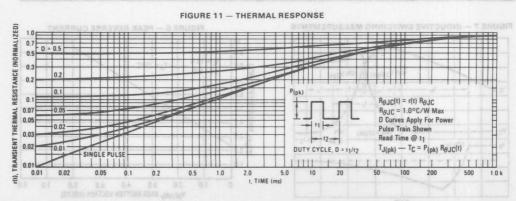
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user-oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.

#### INDUCTIVE SWITCHING





#### FIGURE 10 - CROSSOVER AND FALL TIMES 1.0 Bf = 5.0 = 75°C $T_J$ VBE(off) 0.7 0.5 (ST 0.3 TIME 0.2 5.0 \ -- tfi 0.1 20 5.0 7.0 15 2.0 3.0 IC. COLLECTOR CURRENT (AMPS)



The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

FIGURE 12 — FORWARD BIAS SAFE OPERATING AREA MJ13090 and MJ13091

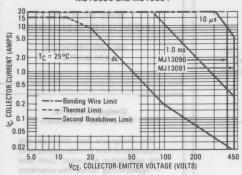
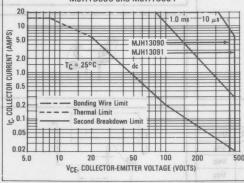


FIGURE 13 — FORWARD BIAS SAFE OPERATING AREA MJH13090 and MJH13091



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 12 and 13 are based on  $T_C$  =  $25^{\circ}C;$   $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C.$  Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 12 and 13 may be found at any case temperature by using the appropriate curve on Figure 15.

T<sub>J</sub>(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse-biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives RBSOA characteristics.



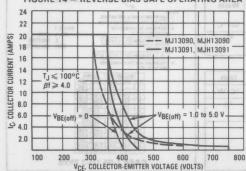
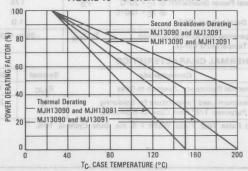


FIGURE 15 - POWER DERATING



## Designer's Data Sheet

# SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The MJ13100 and MJ13101 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
  - Motor Controls
  - Deflection Circuits

Fast Turn-Off Times

30 ns Inductive Fall Time @ 25°C (Typ) 50 ns Inductive Crossover Time @ 25°C (Typ) 900 ns Inductive Storage Time @ 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads
Switching Times with Inductive Loads
Saturation Voltages

current conditions during reverse biased turn-off. This

Leakage Currents as an A primary of the and

## 20 AMPERE

## NPN SILICON POWER TRANSISTORS

400 AND 450 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



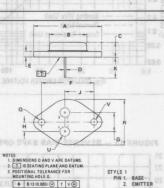
## MAXIMUM RATINGS love has of betseldue reven el enven

Rating	Symbol	MJ13100	MJ13101	Unit
Collector-Emitter Voltage	VCEO(sus)	400	450	Vdc
Collector-Emitter Voltage	VCEV	650	750	Vdc
Emitter Base Voltage	VEB	6.0		Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	20 30		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	10 15		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	175 100 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

#### THERMAL CHARACTERISTICS

no at					
Characteristic	Symbol	Max	Unit		
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.0	°C/W		
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	ToT mat Direction	275	°C		

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

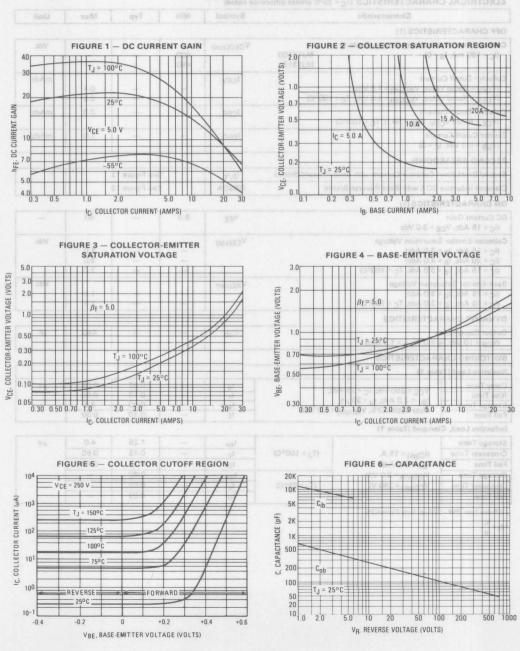


2. EMITTER CASE COLLECT

CASE 1-05 TO-3 TYPE

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) Symbol Max Characteristic Min Тур Unit OFF CHARACTERISTICS (1) Collector-Emitter Sustaining Voltage (Table 1) Vdc VCEO(sus) MJ13100 400 $(I_C = 100 \text{ mA}, I_B = 0)$ MJ13101 450 Collector Cutoff Current ICEV (V<sub>CEV</sub> = Rated Value, V<sub>BE(off)</sub> = 1.5 Vdc) (V<sub>CEV</sub> = Rated Value, V<sub>BE(off)</sub> = 1.5 Vdc, T<sub>C</sub> = 100°C) 0.5 2.5 Collector Cutoff Current 3.0 mAdc CER (V<sub>CE</sub> = Rated V<sub>CEV</sub>, R<sub>BE</sub> = 50 $\Omega$ , T<sub>C</sub> = 100°C) **Emitter Cutoff Current** 1.0 **IEBO** mAdc (VEB = 6.0 Vdc, IC = 0) SECOND BREAKDOWN See Figure 12 Second Breakdown Collector Current with Base Forward Biased Is/b RBSOA See Figure 13 Clamped Inductive SOA with Base Reverse Biased ON CHARACTERISTICS (1) DC Current Gain 8.0 40 hFE $(I_C = 15 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$ Collector-Emitter Saturation Voltage VCE(sat) Vdc (I<sub>C</sub> = 15 Adc, I<sub>B</sub> = 3.0 Adc) (I<sub>C</sub> = 20 Adc, I<sub>B</sub> = 4.0 Adc) (I<sub>C</sub> = 15 Adc, I<sub>B</sub> = 3.0 Adc, T<sub>C</sub> = 100°C) 1.0 3.0 2.0 Base-Emitter Saturation Voltage VBE(sat) Vdc (IC = 15 Adc, IB = 3.0 Adc) 1.5 (IC = 15 Adc, IB = 3.0 Adc, TC = 100°C) 1.5 DYNAMIC CHARACTERISTICS **Output Capacitance** Cob 450 pF (V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f<sub>test</sub> = 1.0 kHz) SWITCHING CHARACTERISTICS Resistive Load (Table 1) Delay Time 0.02 0.05 td шS V<sub>CC</sub> = 250 Vdc, I<sub>C</sub> = 15 Adc, 0.13 0.50 Rise Time $I_{B1} = 2.0 \text{ Adc, } t_p = 30 \mu s,$ Duty Cycle $\leq 2\%$ , $V_{BE(off)} = 5.0 \text{ Vdc)}$ 0.90 3.5 Storage Time ts Fall Time tf 0.10 0.50 Inductive Load, Clamped (Table 1) Storage Time 1 25 tsv 40 Crossover Time (I<sub>C(pk)</sub> = 15 A, (T.1 = 100°C) 0.15 0.50 tc IB1 = 2.0 Adc, Fall Time 0.13 0.40 tfi VBE(off) = 5.0 Vdc, Storage Time 0.90 tsv 0.05 Crossover Time VCE(pk) = 250 V) (TJ = 25°C) Fall Time tfi (1) Pulse Test: PW - 300 µs, Duty Cycle ≤2%. \* $\beta_f = \frac{I_C}{I_B}$

#### DC CHARACTERISTICS



RESISTIVE SWITCHING VCEO(sus) **RBSOA AND INDUCTIVE SWITCHING** Q+V = 11 V 0 02 μF 100 HP 214 or Equiv 20 PG 10 UF RB1 20 R<sub>B2</sub> CONDITIONS 丰 ★ 0 02 UF IB1 adjusted to obtain the forced 10 µF ₹ 50 +) 2N5337 heE desired TURN OFF TIME PW Varied to Attain 500 Use inductive switching IC = 100 mA driver as the input to the resistive test circuit. 100 Adjust R1 to obtain IB1 For switching and RBSOA, R2 = 0 For BVCEO(sus). R2 = « CIRCUIT L<sub>coil</sub> = 180 μH R<sub>coil</sub> = 0.05 Ω V<sub>CC</sub> = 20 V L<sub>coil</sub> = 80 mH V<sub>CC</sub> = 10 V R<sub>coil</sub> = 0.7 12 V<sub>CC</sub> = 250 V V<sub>clamp</sub> = 250 V Rg adjusted to attain desired l<sub>B1</sub> R<sub>L</sub> = 16.6 Ω Pulse Width = 30 μs RESISTIVE TEST CIRCUIT INDUCTIVE TEST CIRCUIT OUTPUT WAVEFORMS t<sub>1</sub> Adjusted to Obtain I<sub>C</sub> CIRCUITS TUT VCC Lcoil (ICM) TEST ( V<sub>clamp</sub> **Detailed Conditions** VCEM Test Equipment Scope - Tektronix 475 or Equivalent -12-

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

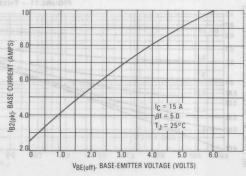
#### FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS

1C pk VCE(pk) 90% 1C(pk)

1C 1sv 1rv 1r, 10% VCE(pk) 10% 1 C(pk)

1B 90% 1B 1 10% VCE(pk) 10% 2% 1C-

FIGURE 8 — PEAK REVERSE CURRENT



#### SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

trv = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms

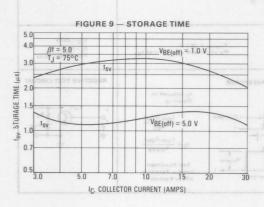
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

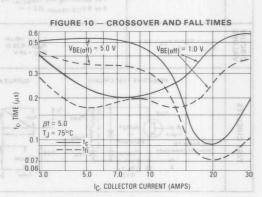
PSWT = 1/2 VCCIC(tc)f

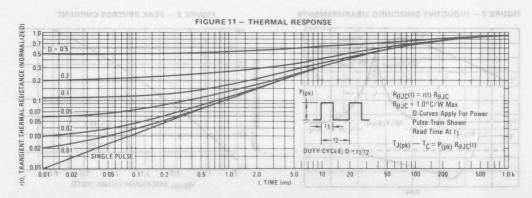
In general,  $t_{rv}$  +  $t_{fi}$   $\simeq$   $t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are quaranteed at 100°C.

#### INDUCTIVE SWITCHING







COLLECTOR

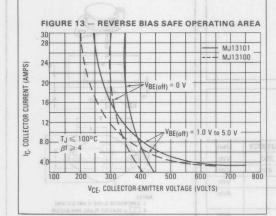


The Safe Operating Area figures shown in figure 12 and 13 are specified for these devices under the test conditions shown

# FIGURE 12 — FORWARD BIAS SAFE OPERATING AREA 30 10 10 7.0 5.0 2.0 1.0 ms MJ13100+ MJ13101M

Thermal Limit (Single Pulse)
Second Breakdown Limit

0 20 30 50 70 100 20
VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

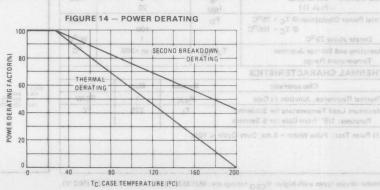
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C=25^{\circ}\text{C}$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^{\circ}\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the RBSOA characteristics.





## Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJ13330 and MJ13331 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Inverters
- Solenoid and Relay Drivers
- Motor Controls 1949 your biley are stimil salug
- Deflection Circuits

Fast Turn-Off Time

75 ns Inductive Fall Time—25°C (Typ)
150 ns Inductive Crossover Time—25°C (Typ)
900 ns Inductive Storage Time—25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents



#### NPN SILICON POWER TRANSISTORS

200 and 250 VOLTS 175 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



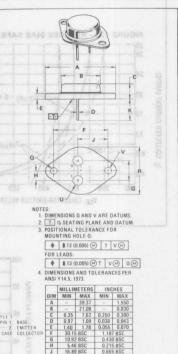
#### MAXIMUM RATINGS

INFORMATION INFORMATION		ENTL LUC TO		
ola oniger Rating seal poidder	Symbol	MJ13330	MJ13331	Unit
Collector-Emitter Voltage	VCEO(sus)	svel 200	250	Vdc
Collector-Emitter Voltage	VCEV	400	450	Vdc
Emitter Base Voltage	VEB	ils continue	3	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	yen al esiva	0	Adc
Base Current - Continuous - Peak (1)	I <sub>B</sub>	2	0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$	P <sub>D</sub>	H DERATIN	75 03 - 86	
Derate above 25°C	The state of		1	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+200	°C

#### THERMAL CHARACTERISTICS

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					
Characteristic	Symbol	Max	Unit		
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1	°C/W		
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C		

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle  $\leq$  10%

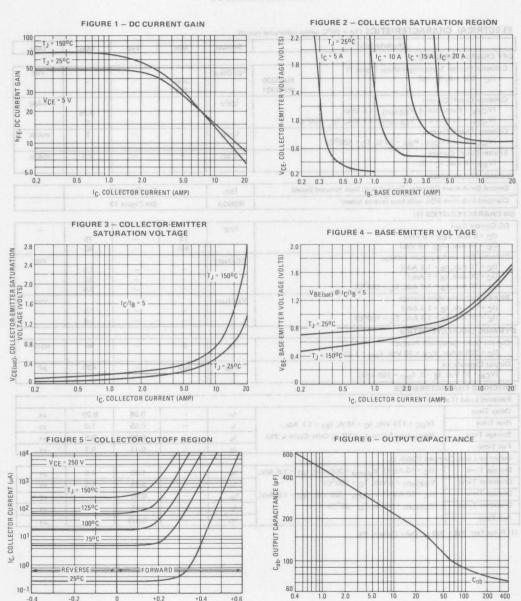


Similar device types with higher  $V_{\mbox{CEO}}$  ratings are: MJ13332 (350 V) thru MJ13335 (500 V).

#### DC CHARACTERISTICS

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS		444	- James C		71-25
Collector-Emitter Sustaining Voltage (Table 1)	VCEO(sus)				Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0) MJ13330 MJ13331	020(303)	200 250			100
Collector Cutoff Current	ICEV				mAdc
$(V_{CEV} = Rated Value, V_{BE(off)} = 1.5 Vdc)$ $(V_{CEV} = Rated Value, V_{BE(off)} = 1.5 Vdc, T_{C} = 150^{\circ}C)$			-	0.25	20
Collector Cutoff Current ( $V_{CE}$ = Rated $V_{CEV}$ , $R_{BE}$ = 50 $\Omega$ , $T_{C}$ = 100°C)	ICER	II †	- -	5	mAdc
Emitter Cutoff Current (VEB = 6 Vdc, IC = 0)	IEBO		-	0.5	mAdc
SECOND BREAKDOWN	05 01	0.0	0.5	0.5	0.2
Second Breakdown Collector Current with base forward biased	I <sub>S/b</sub>	SHAUTE	See Figure 12	No al	
Clamped Inductive SOA with base reverse biased	RBSOA	13 EN 19	See Figure 13		
ON CHARACTERISTICS (1)	NBSUA		oce rigure 13		
DC Current Gain	b 1	12171003-71	F103 1300 -	FIGURES	
(IC = 5 Adc, VCE = 5 Vdc)	pEE	15	DV WOLTARI	75	
(IC = 10 Adc, VCE = 5 Vdc)	CT OF	8.0	1-1	40	1 18
Collector-Emitter Saturation Voltage	VCE/sex	0.0			Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.5 Adc)	VCE(sat)		-	1.5	Vac
(I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 5 Adc)	1 00051 - 1			3.5	
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.8 Adc, T <sub>C</sub> = 100°C)		-	-	2.5	0.
Base-Emitter Saturation Voltage	VBE(sat)		- ic = sl\n1		Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.5 Adc)		1 4		1.8	
$(I_C = 10 \text{ Adc}, I_B = 1.8 \text{ Adc}, T_C = 100^{\circ}\text{C})$	A IV II	-	- 1	1,8	
DYNAMIC CHARACTERISTICS				And the second	
Current-Gain-Bandwidth Product (IC = 300 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 1 MHz)	fT.	5		40	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f <sub>test</sub> = 100 kHz)	Cob	100		400	pF
WITCHING CHARACTERSITICS	95 91	6.8	0.8	Er an	0.2
Resistive Load (Table 1) WIRRAG AUTHOUSE		(8RA) TV3	Mend Resolution	12.51	
Delay Time	t <sub>d</sub>		0.08	0.20	us
Rise Time (V <sub>CC</sub> = 175 Vdc, I <sub>C</sub> = 10 A, I <sub>R1</sub> = 1.5 Adc,	tr	_	0.55	1.0	us
Storage Time $V_{BE(off)} = 5 \text{ Vdc}, t_p = 50 \mu \text{s}, \text{ Duty Cycle} \le 2\%$	ts	DED STEARS	0.70	3.5	μs
Fall Time	tf	A10 311 110	0.11	0.7	μς
Inductive Load, Clamped (Table 1)	A	TITLE		0.7	μs
Storage Time (I <sub>C</sub> = 10 A(pk), V <sub>clamp</sub> = 200 Vdc, I <sub>B1</sub> = 1.8 Adc,	t <sub>sv</sub>		1.35	4.5	μs
Crossover Time V <sub>BE</sub> (off) = 5 Vdc, T <sub>C</sub> = 100°C)	100000000000000000000000000000000000000	+ 14	0.45	1.8	
Storage Time $(I_C = 10 \text{ A(pk)}, V_{clamp} = 200 \text{ Vdc}, I_{B1} = 1.5 \text{ Adc},$	t <sub>c</sub>	1-1-1	0.45	1.0	μs
Crossover Time V <sub>BE</sub> (off) = 5 Vdc, T <sub>C</sub> = 25°C)	t <sub>sv</sub>	1		1000	μs
ARE(011) 2 Age, 1C - 52 Cl	t <sub>c</sub>	1-4-7	0.15		μς
Fall Time	tfi		0.075	20001	μs

# DC CHARACTERISTICS



VBE, BASE-EMITTER VOLTAGE (VOLTS)

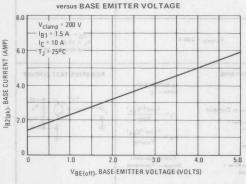
VR, REVERSE VOLTAGE (VOLTS)

# DIAMOTHUS SVITOUGHI GIA AGRES SWITCHING TIMES NOTE

FIGURE 7 – INDUCTIVE SWITCHING MEASUREMENTS

ICPK
Vclamp
90% Vclamp
10%
Vclamp

FIGURE 8 - REVERSE BASE CURRENT versus BASE EMITTER VOLTAGE



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

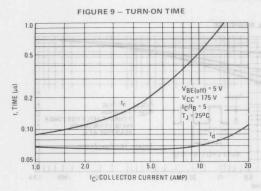
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv}$  +  $t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $(t_{\text{\tiny C}}$  and  $t_{\text{\tiny SW}})$  which are guaranteed at  $100^{\circ}\text{C}$ .

### **RESISTIVE SWITCHING**



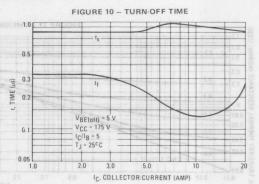
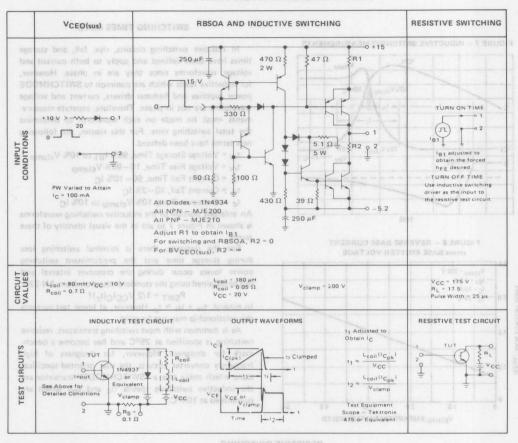
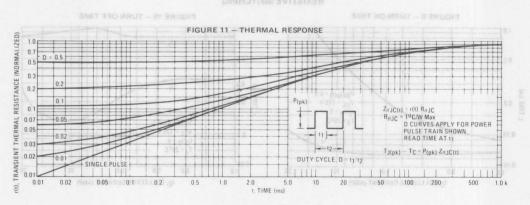


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

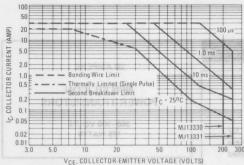




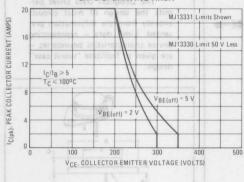
MOTOROLA

# SAFE OPERATING AREA INFORMATION

# FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA



# FIGURE 13 – REVERSE BIAS SWITCHING SAFE OPERATING AREA



### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

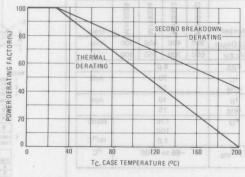
The data of Figure 12 is based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 c.iay be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J(pk)</sub> may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.

# FIGURE 14 - POWER DERATING





# Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJ13332 through MJ13335 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated 

- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits applied doing about aviroubnit to 1

Fast Turn-Off Times of this by lauromethania benintaus

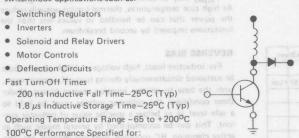
200 ns Inductive Fall Time-25°C (Typ) 1.8 μs Inductive Storage Time—25°C (Typ)

Operating Temperature Range –65 to +200°C Operating Temperature Range –65 to +200°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages prompt aldewella sombros

Leakage Currents



# MAXIMUM RATINGS

Rating	Symbol	MJ13332	MJ13333	MJ13334	MJ13335	Unit
Collector-Emitter Voltage	VCEO(sus)	350	400	450	500	Vdc
Collector-Emitter Voltage	VCEV	650	700	750	800	Vdc
Emitter Base Voltage	VEB	6.0		Vdc		
Collector Current - Continuous Peak (1)	I <sub>C</sub> M	20 30			Adc	
Base Current — Continuous Peak (1)	I <sub>B</sub>	10 15		Adc		
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	175 100 1.0		Watts W/°C		
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	(8)	-65 to	+200		°C A3.31

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

Similar device types available with lower VCEO ratings, see the MJ13330 (200 V) and MJ13331 (250 V).

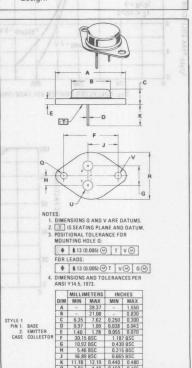
# 20 AMPERE

# NPN SILICON POWER TRANSISTORS

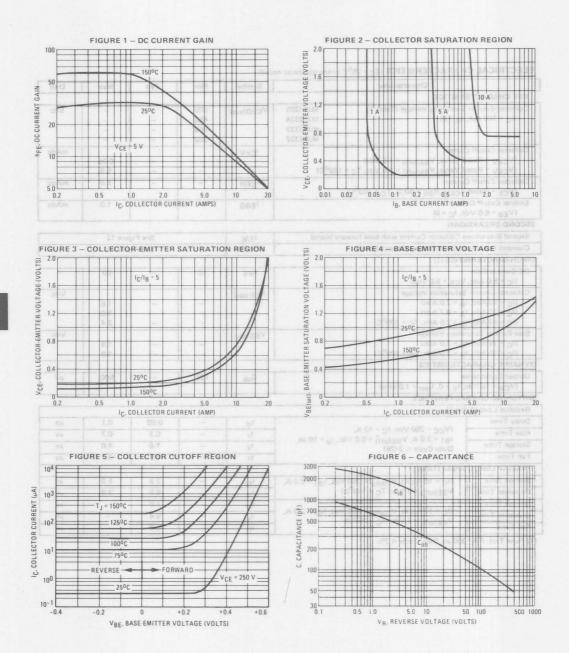
350-500 VOLTS 175 WATTS

### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design

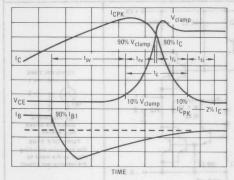


LECTRICAL CH	IARACTERISTICS (T <sub>C</sub> = 25°C unless o	therwise no			30081		
	Characteristic	5	Symbol	Min	Тур	Max	Unit
OFF CHARACTER		0	1	500			1/4-
(IC = 100 mA,		IJ13335 IJ13334	VCEO(sus)	500 450	1 50	MELL	Vdc
(IC - 100 IIIA,	D T T	1J13333	1	400			05
	M	1J13332		350	-		-
Collector Cutoff Co	urrent	E.	ICEV			9	mAdc
	Value, V <sub>BE(off)</sub> = 1.5 Vdc)					0.25	
	Value, $V_{BE(off)} = 1.5 \text{ Vdc}$ , $T_{C} = 150^{\circ}\text{C}$	5	11		-	5.0	
Collector Cutoff C			CER		-	5.0	mAdc
	VCEV, RBE = 50 Ω, T <sub>C</sub> = 100°C)		10 20	5.0.2	2.0 2.0 Calleran Cuns	1.0	mAdc
(V <sub>EB</sub> = 6.0 Vdd			IEBO	100000000000000000000000000000000000000		1.0	made
SECOND BREAKDO	*						
	Collector Current with base forward biase	d	IS/b		See Figu	re 12	
	SOA with Base Reverse Biased		RBSOA	ATURATH	See Figu		GURE3 -
ON CHARACTERIS		X	4 1 (1)	TTT		TITTE	700
DC Current Gain		2	hee	10	T - T	60	
(IC = 5.0 Adc, )	VCE = 5.0 Vdc)				9 8/01		la.
Collector-Emitter Saturation Voltage (IC = 10 Adc, Ig = 2.0 Adc) (IC = 20 Adc, Ig = 6.7 Adc) (IC = 10 Adc, Ig = 2.0 Adc, TC = 100°C)		5	VCE(sat)	MILE			Vdc
		N. H			1.8		
					5.0	12	
Base-Emitter Satur	Management of the country of the cou	20.	Voca			2,7	Vdc
(IC = 10 Adc, I			VBE(sat)			1.8	181
	B = 2.0 Adc, T <sub>C</sub> = 100°C)		10			1.8	
DYNAMIC CHARAC		1	THE HIN	200			
Output Capacitano	e	6	Cob	125	2500 -	500	pF
(V <sub>CB</sub> = 10 Vdc	, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)				36021		
SWITCHING CHAR	ACTERISTICS	Ē.	Dr. Dr	. 0.0	1.0 2.0	0.5	0.0
Resistive Load (Tal	ble 1) and normalism get	-		(9MALTINS	янсо потавицоз	01	
Delay Time	/V 250 V/J- 1 - 10 A		t <sub>d</sub>		0.02	0.1	μs
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 10 A, I <sub>B1</sub> = 2.0 A, V <sub>BE(off)</sub> = 5.0 Vdc, t <sub>p</sub> = 1	10 415	t <sub>r</sub>	-	0.3	0.7	μs
Storage Time	Duty Cycle ≤ 2.0%)	ιο μο,	ts		1.6	4.0	μs
Fall Time			tf	BURLING	0.3	0.7 JAL	μs
Inductive Load, Cla	amped (Table 1)	0.005	A TAN				
Storage Time	(I <sub>C</sub> = 10 A(pk), V <sub>clamp</sub> = 250 Vdc, I <sub>B1</sub>	= 2.0 A,	t <sub>sv</sub>	7-1	2.5	5.0	μς
Crossover Time	VBE(off) = 5 Vdc, T <sub>C</sub> = 100°C)		t <sub>c</sub>	1	0.8	2.0	μς
Storage Time	(In = 10 A (ak) )/ = 250 )/ i	- 20 4	t <sub>sv</sub>	1-1-	1.8	79021-LT-	μς
Crossover Time	$(I_C = 10 \text{ A(pk)}, V_{clamp} = 250 \text{ Vdc}, I_{B1}$ $V_{BE(off)} = 5 \text{ Vdc}, T_C = 25^{\circ}C)$	- 2.0 A,	tc	C PC	0.4	3000	μѕ
Fall Time	- BE(011) - 1.00, 1C 20 07		- tfi	7-1	0.2		μς
1) Pulse Test: PW -	300 µs, Duty Cycle ≤ 2%.	um &				00001	
					ALVRO R-ST		

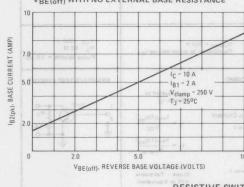


# SWITCHING TIMES NOTE





# FIGURE 8 - REVERSE BASE CURRENT versus VBE(off) WITH NO EXTERNAL BASE RESISTANCE



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

trv = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90 - 10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

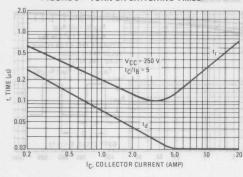
PSWT = 1/2 VCCIC(tc)f

In general,  $t_{rv}$  +  $t_{fi} \simeq t_c$ . However, at lower test currents this relationship may not be valid.

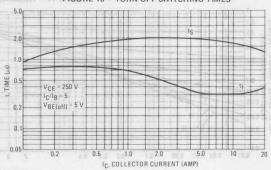
As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

# RESISTIVE SWITCHING PERFORMANCE

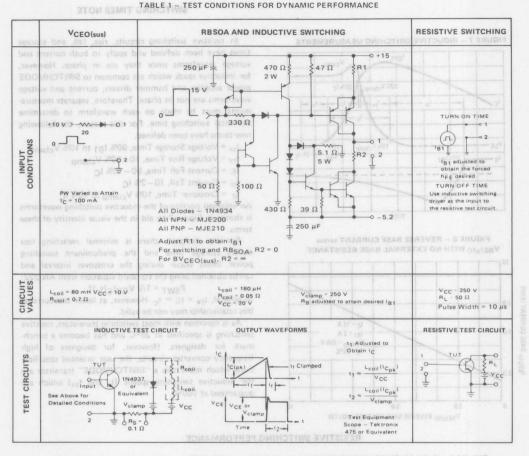
FIGURE 9 - TURN-ON SWITCHING TIMES

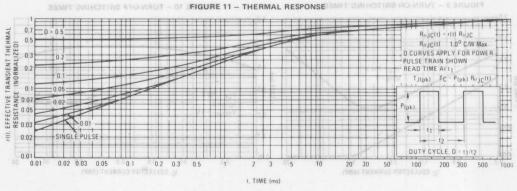


# FIGURE 10 - TURN-OFF SWITCHING TIMES



MJ13332, MJ13333, MJ13334, MJ13335





3

# MOTOROLA

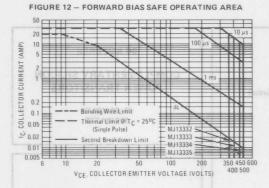
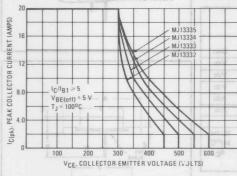


FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



# FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

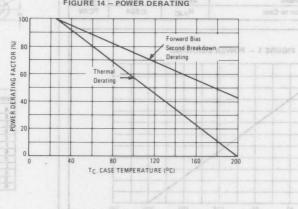
The data of Figure 12 is based on  $T_C$  =  $.25^{o}C$ :  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.







# HIGH-CURRENT COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for use in high-power amplifier and switching circuit applications.

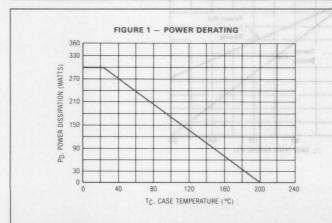
- High Current Capability IC Continuous = 60 Amperes
- DC Current Gain hFE = 15-100 @ IC = 50 Adc
- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 2.5 Vdc (Max) @ IC = 50 Adc

# MAXIMUM RATINGS

29250 feora ni ,flo-mut panub Rating , aver notice	Symbol	MJ14000 MJ14001	MJ14002 MJ14003	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCBO	60	80	Vdc
Emitter-Base Voltage	VEBO	This can I	5 nsn	Vdc
Collector Current - Continuous	de le de	oniomale 60 na		Adc
Base Current — Continuous	B see	er 1 101 leve 15 les		Adc
Emitter Current - Continuous	bast Essa A	A persengal 75 as		-
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	SCHOOL STUDY	.7	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+200	°C

# THERMAL CHARACTERISTICS

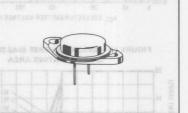
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.584	°C/W

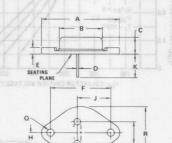


# 60 AMPERES

# COMPLEMENTARY SILICON POWER TRANSITORS

60-80 VOLTS 300 WATTS





CASE 197-01 TO-204AE

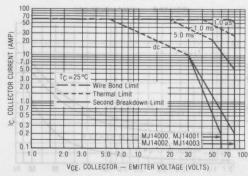
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# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS				.,	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	MJ14000, MJ14001 MJ14002, MJ14003	VCEO(sus)	60 80		Vdc
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 40 Vdc, I <sub>B</sub> = 0)	MJ14000, MJ14001 MJ14402, MJ14003	CEO	1-11	1.0	mA
Collector Cutoff Current (VCE = 60 Vdc, VBE(off) = 1.5 V) (VCE = 80 Vdc, VBE(off) = 1.5 V)	MJ14000, MJ14001 MJ14002, MJ14003	ICEX	-	1.0	mA 08
Collector Cutoff Current (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	MJ14000, MJ14001 MJ14002, MJ14003	СВО	-	1.0	mA
Emitter Cutoff Current (VBE = 5 Vdc, I <sub>C</sub> = 0)	7.0	IEBO	1-1-11	1.0	mA 0
ON CHARACTERISTICS	30110 20	11 OH OE	ns 01 n	02 00 05	A ALLIE
DC Current Gain (1) (1) (104 000 000 000 000 000 000 000 000 000		hFE	30 15 5	100	-
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2.5 Adc) (I <sub>C</sub> = 50 Adc, I <sub>B</sub> = 5.0 Adc) (I <sub>C</sub> = 60 Adc, I <sub>B</sub> = 12 Adc)	2.8 2.4 - 1, -25°C	VCE(sat)	<b>/</b> -E1	1 2.5 3	Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 25 Adc, I <sub>B</sub> = 2.5 Adc) (I <sub>C</sub> = 50 Adc, I <sub>B</sub> = 5.0 Adc) (I <sub>C</sub> = 60 Adc, I <sub>B</sub> = 12 Adc)	9.5 E	VBE(sat)		2 3 4	Vdc
OYNAMIC CHARACTERISTICS	1 1 31 8 1				1/15
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)	A01-31 / 180 E	C <sub>ob</sub>	15	2000	pF

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.

# FIGURE 2 — MAXIMUM RATED FORWARD BIASED SAFE OPERATING AREA



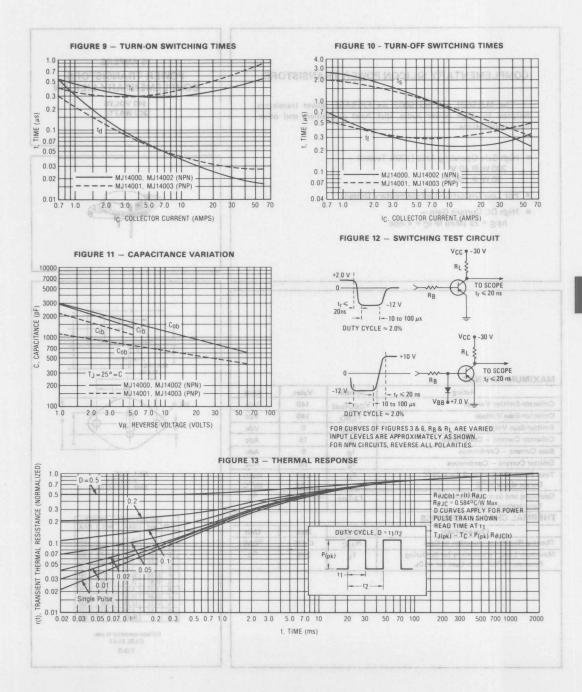
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 13. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

### TYPICAL ELECTRICAL CHARACTERISTICS 20172189TGARAHO JADISTO9J3 PNP NPN MJ14001, MJ14003 MJ14000, MJ14002 FIGURE 3 - DC CURRENT GAIN FIGURE 4 - DC CURRENT GAIN 300 3001 100 GAIN 50 50 DC CURRENT 30 20 20 00 7.0 5.0 3.0 0.7 1.0 2.0 3.0 5.0 7.0 10 30 50 70 2.0 3.0 5.0 7.0 10 IC. COLLECTOR CURRENT (AMPS) IC. COLLECTOR CURRENT (AMPS) 68 144-100 30 FIGURE 5 - COLLECTOR SATURATION REGION FIGURE 6 - COLLECTOR SATURATION REGION COLLECTOR-EMITTER VOLTAGE (VOLTS) (NOLTS) TJ = 25°C TJ = 25°C IC = 60 A IC = 60 A ECTOR-EMITTER VOLTAGE 2.0 2.0 1.2 IC = 10 A 0.8 COL 0.4 0.4 VCE. VCE. 0.5 0.7 1.0 2.0 3.0 IB. BASE CURRENT (AMPS) IB. BASE CURRENT (AMPS) FIGURE 2 - MAXIMUM RATED FORWARD BIASED FIGURE 7 - "ON" VOLTAGES FIGURE 8 - "ON" VOLTAGES T1=25°C T.1=25°C VOLTAGE (VOLTS) (VOL 1.6 VOLTAGE VBE(sat) @ IC/IB = 10 VBE(on) @ VCE = 3.0 V VCE(sat) @ IC/IB = 10 0.4 VCE(sat) @ IC/IB = 10 3.0 5.0 7.0 10 50 70 5.0 7.0 10 IC. COLLECTOR CURRENT (AMPS) IC. COLLECTOR CURRENT (AMPS)









# COMPLEMENTARY SILICON POWER TRANSISTORS

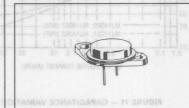
FIGURE 10 - TURN-OFF SWITCHING TIMES

The MJ15001 and MJ15002 are EPIBASE power transistors designed for high power audio, disk head positioners and other linear applications.

- High Safe Operating Area (100% Tested) –
   200 W @ 40 V
   50 W @ 100 V
- For Low Distortion Complementary Designs
- High DC Current Gain hFE = 25 (Min) @ IC = 4 Adc

15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
140 VOLTS

200 WATTS



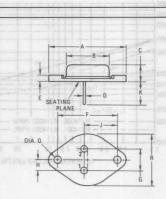
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# MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	140	Vdc
Collector-Base Voltage	V <sub>CBO</sub>	140	Vdc
Emitter-Base Voltage Av 38A ya a 8 8 8 8 8 8 8 8 8	VEBO	5	Vdc
Collector Current — Continuous	lc	15	Adc
Base Current — Continuous	I <sub>B</sub>	5	Adc
Emitter Current - Continuous	1E	20	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	200	Watts W/OC
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200	°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	0.875	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/16" from Case for ≤10s.	TL (8)	265	°C



PIN 1. BASE 2. EMITTER CASE: COLLECTOR

	MILLI	METERS	INC	CHES	
DIM	MIN	MAX	MIN	MAX	
A	124	39.37		1.550	
В	3-	21.08	44	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	0.039	0.043	
E	-30	3.43		0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
H	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.84	4.09	0.151	0.161	
R	0-0	26.67	0.8.20	1.050	

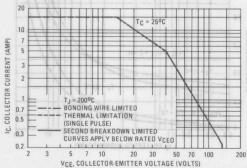
CASE 11-01
TO-3

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (IC = 200 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	140		Vdc
Collector Cutoff Current	CEX	1		
( V <sub>CE</sub> = 140 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc) ( V <sub>CE</sub> = 140 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	0.0	1-1-	100	μAdc mAdc
Collector Cutoff Current (VCE = 140 Vdc, I <sub>B</sub> = 0)	ICEO		250	μAdc
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0)	IEBO		100	μAdc
SECOND BREAKDOWN		1949 (8	0113100000	
Second Breakdown Collector Current with Base Forward Biased (VCF = 40 Vdc, t = 1s (non-repetitive))	Is/b	5		Adc
(VCE = 40 Vdc, t = 1s (non-repetitive)) (VCE = 100 Vdc, t = 1,s (non-repetitive)	50 20 169 160	0.5	01 <u>X</u> 0	5 2 3
ON CHARACTERISTICS		TOTAL SURF	Or dondy an in Y	
DC Current Gain (IC = 4 Adc, VCE = 2 Vdc)	hFE	25	150	-
Collector-Emitter Saturation Voltage (IC = 4 Adc, I <sub>B</sub> = 0.4 Adc)	VCE(sat)	- 10	arum 1	Vdc
Base-Emitter On Voltage (IC = 4 Adc, VCE = 2 Vdc)	VBE(on)		2	Vdc
DYNAMIC CHARACTERISTICS				1985
Current-Gain — Bandwidth Product (IC = 0.5 Adc, VCE = 10 Vdc, f <sub>test</sub> = 0.5 MHz)	f <sub>T</sub>	2		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f <sub>test</sub> = 1 MHz)	C <sub>ob</sub>		1000	pF

(1) Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\leq$  2%.

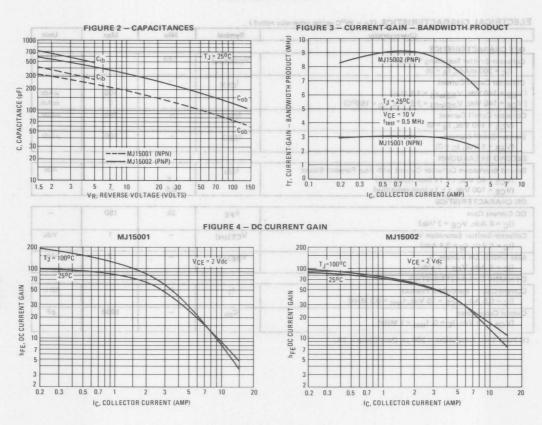
FIGURE 1 - ACTIVE-REGION SAFE OPERATING AREA

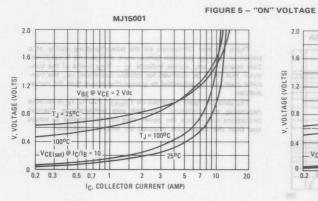


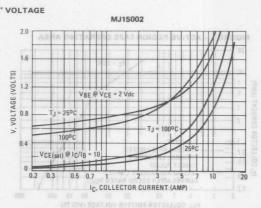
There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# TYPICAL CHARACTERISTICS







The MJ15003 and MJ15004 are PowerBase power transistors designed for high power audio, disk head positioners and other linear applications.

- High Safe Operating Area (100% Tested) –
   250 W @ 50 V
- For Low Distortion Complementary Designs
- High DC Current Gain –
   hFE = 25 (Min) @ IC = 5 Adc

# 20 AMPERE

# POWER TRANSISTORS COMPLEMENTARY SILICON

140 VOLTS 250 WATTS

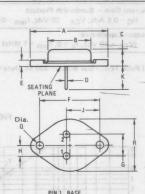


# MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	140	Vdc
Collector-Base Voltage	VCBO	140	Vdc
Emitter-Base Voltage	VEBO	5	Vdc
Collector Current — Continuous	IC	20	Adc
Base Current — Continuous	IВ	5	Adc
Emitter Current - Continuous	IE	25	Adc
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C		250 ota 1.43	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +200	°C

# THERMAL CHARACTERISTICS

reulay or ballor Characteristic reason and ap	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.70	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/16" from Case for ≤10s.	TL	265	°C



PIN 1. BASE 2. EMITTER CASE: COLLECTOR

JWW	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	-	39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	-	3.43	1-1	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	-	26.67		1.050

CASE 11-01

TO-3

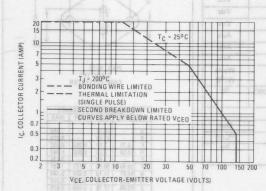
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\*ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (IC = 200 mAdc, IB = 0)	SHUTEISM	VCEO(sus)	140	LEMENTAR	Vdc
Collector Cutoff Current { VCE = 140 Vdc, VBE(off) = 1.5 Vdc} ( VCE = 140 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	er transistors	CEX	U15004 are F	100 1 bm 200314.1	μAdc mAdc
Collector Cutoff Current (VCE = 140 Vdc, IB = 0)	realto fina et	ener ICEO paer	audio, disk	250	μAdc
Emitter Cutoff Current (VEB = 5 Vdc, IC = 0)		1EBO		100	μAdc
SECOND BREAKDOWN		- (ba)	mer (100% Test	afe Operating A	# High S
Second Breakdown Collector Current with Base Forward B $(V_{CE} = 50 \text{ Vdc}, t = 1 \text{ s (non-repetitive)}$ $(V_{CE} = 100 \text{ Vdc}, t = 1 \text{ s (non-repetitive)}$	Biased	IS/b angland	5 V36345 <b>1</b> 064qme	V @ 90 V - W Distortion Co	Adc Adc
ON CHARACTERISTICS					
DC Current Gain (I <sub>C</sub> = 5 Adc, V <sub>CE</sub> = 2 Vdc)		hFE	25 200	150	Jah
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5 Adc, I <sub>B</sub> = 0.5 Adc)		VCE(sat)		1	Vdc
Base-Emitter On Voltage (IC = 5 Adc, VCE = 2 Vdc)		VBE(on)		2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (IC = 0.5 Adc, VCE = 10 Vdc, f <sub>test</sub> = 0.5 MHz)		f <sub>T</sub>	2	_	MHz
Output Capacitance (VCR = 10 Vdc, IF = 0, f <sub>test</sub> = 1 MHz)		C <sub>ob</sub>		1000	pF

(1) Pulse Test: Pulse Width - 300 µs, Duty Cycle - 2%.



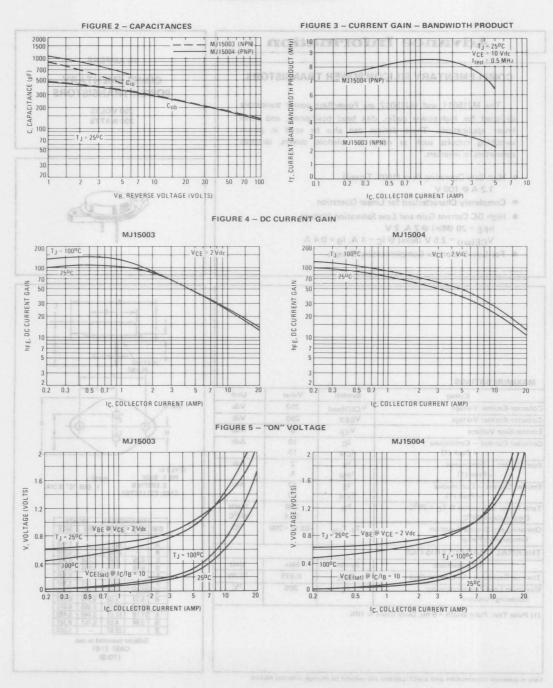


There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC = VCg Elmits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_J(pk) = 200^{\circ}C$ ;  $T_C$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

3

# TYPICAL CHARACTERISTICS





TYPICAL CHARACTERISTICS

# **Advance Information**

# COMPLEMENTARY SILICON POWER TRANSISTORS

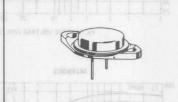
The MJ15011 and MJ15012 are PowerBase power transistors designed for high-power audio, disk head positioners, and other linear applications. These devices can also be used in power switching circuits such as relay or solenoid drivers, dc-to-dc converters or inverters.

- High Safe Operating Area (100% Tested)
   1.2 A @ 100 V
- Completely Characterized for Linear Operation
- High DC Current Gain and Low Saturation Voltage hFE = 20 (Min) @ 2 A, 2 V
   VCE(sat) = 2.5 V (Max) @ IC = 4 A, IB = 0.4 A
- For Low Distortion Complementary Designs

### 10 AMPERE

# COMPLEMENTARY POWER TRANSISTORS

250 VOLTS 200 WATTS



3

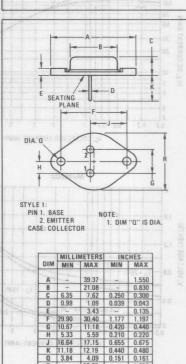
# MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	250	Vdc
Collector-Emitter Voltage	VCEX	250	Vdc
Emitter-Base Voltage	VEB	5 NO.	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	10 15	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	2 5	Adc
Emitter Current — Continuous — Peak (1)	I <sub>E</sub>	12 20	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	200 1.14	Watts W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to +200	°C

I	THERMAL	CHARACTERISTICS
---	---------	-----------------

Symbol	Max Max	Unit
R <sub>θ</sub> JC	0.875	°C/W
TL	265	ос
0.5	0.2	10 20
		R <sub>θ</sub> JC 0.875

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



- 26.67 Collector connected to case.
CASE 11-01
(TO-3)

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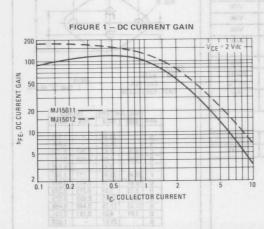
This is advance information and specifications are subject to change without notice.

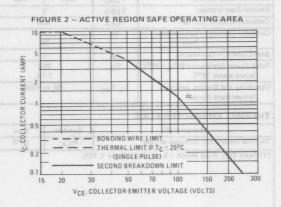


**ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (IC = 100 mA)		VCEO(sus)	250	-	Vdc
Collector Cutoff Current (VCE = 200 Vdc)	RS	CEO	N POWER	siLico	mAdo
Collector Cutoff Current (VCE = 250 Vdc, VBE(off) = 1.5 Vdc)	115 7 25 3	ICEX	-	500	μAdo
Emitter Cutoff Current (VBE = 5 Vdc)	cower transitions		MJ15 <del>0</del> 24 an		μAdc hempirel
ON CHARACTERISTICS (1)				lications,	ода тавої
DC Current Gain (IC = 2 Adc, VCE = 2 Vdc) (IC = 4 Adc, VCE = 2 Vdc)		hFE	20 5	100	2 4 13
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0.2 Adc) (I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.4 Adc)		VCE(sat)	_	0.8 2.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 4 Adc, V <sub>CE</sub> = 2 Vdc)		V <sub>BE</sub> (on)	IC = 8 Ado	o (aith) el =	Vdc
DYNAMIC CHARACTERISTICS					
Output Capacitance (V <sub>CB</sub> = 10 Vdc, f = 1 MHz)		C <sub>ob</sub>	-	750	pF
SECOND BREAKDOWN					
Second Breakdown Collector Current with Base Forwall $(V_{CE} = 40.Vdc, t = 0.5 s)$ $(V_{CE} = 100 Vdc, t = 0.5 s)$	ard Biased	I <sub>S/b</sub>	5 1.4	_	Adc







3



ELECTRICAL CHARACTERISTICS (To = X5°C unless altres

# SILICON POWER TRANSISTORS

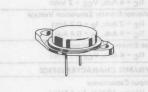
The MJ15022 and MJ15024 are PowerBase power transistors designed for high power audio, disk head positioners and other linear applications.

- High Safe Operating Area (100% Tested) —
   2 A @ 80 V
- High DC Current Gain —
   hFE = 15 (Min) @ IC = 8 Adc

# 16 AMPERE

# SILICON POWER TRANSISTORS

200 and 250 VOLTS 250 WATTS



3

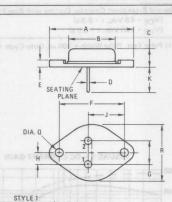
# MAXIMUM RATINGS

Rating	Symbol	MJ15022	MJ15024	Unit
Collector-Emitter Voltage	VCEO	200	250	Vdc
Collector-Base Voltage	VCBO	350	400	Vdc
Emitter-Base Voltage	VEBO		5	Vdc
Collector-Emitter Voltage	VCEX	400		Vdc
Collector Current — Continuous Peak (1)	lc	16 30		Adc
Base Current - Continuous	IB	5		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	250 1.43		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	0.70	°C/W

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE: 1. DIM "Q" IS DIA.

	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
А		39.37	-	1.550
В	-	21.08	-	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E		3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	-	26.67	-	1.050

CASE 1-04
(TO-204AA)

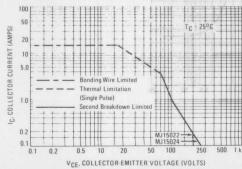
# ELECTRICAL CHARACTERISTICS IS 1200

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJ15022 MJ15024	VCEO(sus)	200 250		
Collector Cutoff Current (V <sub>CE</sub> = 200 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 250 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc)	MJ15022 MJ15024	CEX		250 250	μAdc
Collector Cutoff Current (V <sub>CE</sub> = 150 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 200 Vdc, I <sub>B</sub> = 0)	MJ15022 MJ15024	ICEO		500 500	μAdc
Emitter Cutoff Current was TM38840 A01333300 gt (VCE = 5 Vdc, IB = 0)	Both	IEBO	(st 70A) 19	500	μAdc
SECOND BREAKDOWN					
Second Breakdown Collector Current with Base For (VCE = 50 Vdc, t = 0.5 s (non-repetitive)) (VCE = 80 Vdc, t = 0.5 s (non-repetitive))		I <sub>S/b</sub>	M 5 TM 3 R	RE 4 DC CUR	Adc
ON CHARACTERISTICS	1 1 1 1 1 1 1 1	· ·	Ex roV	STORES TO STORE ST	
DC Current Gain (I <sub>C</sub> = 8 Adc, V <sub>CE</sub> = 4 Vdc) (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 4 Vdc)		hFE	15 5	60	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 0.8 Adc) (I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 3.2 Adc)	0.1	VCE(sat)		1.4 4.0	Vdc
Base-Emitter On Voltage (IC = 8 Adc, VCE = 4 Vdc)		VBE(on)	-	2.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product (IC = 1 Adc, VCE = 10 Vdc, f <sub>test</sub> = 1 MHz)	0 250	f <sub>T</sub>	4		MHz
Output Capacitance (VCB = 10 Vdc, IF = 0, ftest = 1 MHz)	10	Cob	ENNY TARES	500	pF

TYPICAL CHARACTERISTICS

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%.

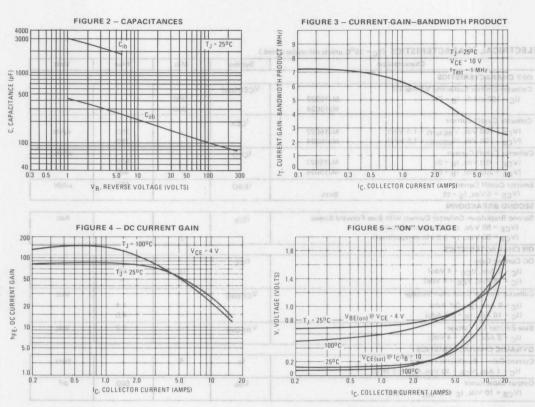


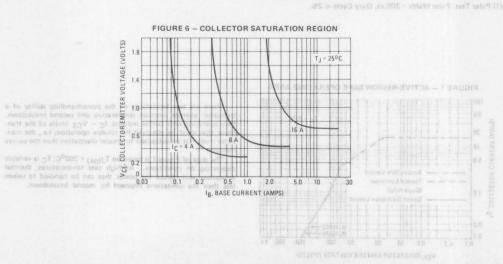


There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $|_{\rm C} - {\rm V}_{\rm CE}|$  fimits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# TYPICAL CHARACTERISTICS





# SILICON POWER TRANSISTORS

The MJ15023 and MJ15025 are PowerBase power transistors designed for high power audio, disk head positioners and other linear applications.

- High Safe Operating Area (100% Tested) -2 A @ 80 V
- High DC Current Gain hFE = 15 (Min) @ IC = 8 Adc

# 16 AMPERE

# SILICON RETDARAND THE POWER TRANSISTORS

200 and 250 VOLTS 250 WATTS TO HOTE OF TOTAL



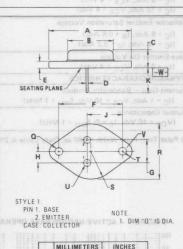
# MAXIMUM RATINGS

Rating	Symbol	MJ15023	MJ15025	Unit
Collector-Emitter Voltage	VCEO	200	250	Vdc
Collector-Base Voltage	VCBO	350	400	Vdc
Emitter-Base Voltage	VEBO		5	Vdc
Collector-Emitter Voltage	VCEX	400		Vdc
Collector Current — Continuous Peak (1)	ıc	16 30		Adc
Base Current - Continuous	IB	5		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	250 1.43		Watts W/ <sup>o</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200		°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rajc	0.70	°C/W

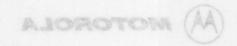
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle · 10%.



	MILLIMETERS		INC	INCHES		
DIM	MIN	MAX	MIN	MAX		
A	-	39.37	-	1.550		
В	-20	21.08	100	0.830		
C	6.35	7.62	0.250	0.300		
D	0.97	1.09	0.038	0.043		
E	1.40	1.78	0.055	0.070		
F	30.1	5 BSC		7 BSC		
G	10.9	10.92 BSC		BSC		
Н	5.4	5.46 BSC		BSC		
J	16.8	9 BSC	0.66	5 BSC		
K	11.18	12.19	0.440	0.480		
0	3.81	4.19	0.150	0.165		
R	-	26.67	-	1.050		
U	2.54	3.05	0.100	0.120		
V	3.81	4.19	0.150	0.165		

(TO-204AA)

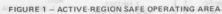
M115025

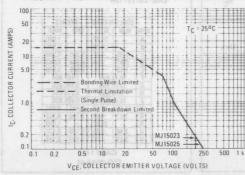


FI	FCTRICAL	CHARACTERISTICS	(Tc = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS		SHUTSTE	MART MAN	ON MODITALE	
Collector-Emitter Sustaining Voltage (1)  (IC = 100 mAdc, IB = 0)	MJ15023 MJ15025	VCEO(sus)	200 250 250	- 923 arti M118	The Mulb
Collector Cutoff Current (V <sub>CE</sub> = 200 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 250 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc)	MJ15023 MJ15025	CEX	idio, disk hea 	250 250	μAdc μΑσ
Collector Cutoff Current (V <sub>CE</sub> = 150 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 200 Vdc, I <sub>B</sub> = 0)	MJ15023 MJ15025	ICEO	100% Testad)	500 500 500	μAdc Data2 rigit 6
Emitter Cutoff Current (VCE = 5 Vdc, IB = 0)	Both	IEBO	-	500	μAdc
SECOND BREAKDOWN				- mail train	DO DO UBSE 6
Second Breakdown Collector Current with Base Forwa (V <sub>CE</sub> = 50 Vdc, t = 0.5 s (non-repetitive)) (V <sub>CE</sub> = 80 Vdc, t = 0.5 s (non-repetitive))	ard Biased	IS/b	5 2	- 31 @ (wild)	Adc
ON CHARACTERISTICS					
DC Current Gain (I <sub>C</sub> = 8 Adc, V <sub>CE</sub> = 4 Vdc) (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 4 Vdc)		hFE	15 5	60	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 0.8 Adc) (I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 3.2 Adc)		VCE(sat)	-	1.4 4.0	Vdc
Base-Emitter On Voltage (IC = 8 Adc, VCE = 4 Vdc)		V <sub>BE</sub> (on)	-	2.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product (IC = 1 Adc, VCE = 10 Vdc, f <sub>test</sub> = 1 MHz)		f <sub>T</sub>	4	- 80	MHz METASI MUM
Output Capacitance		Cob		600	pF

(1) Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\leq$  2%

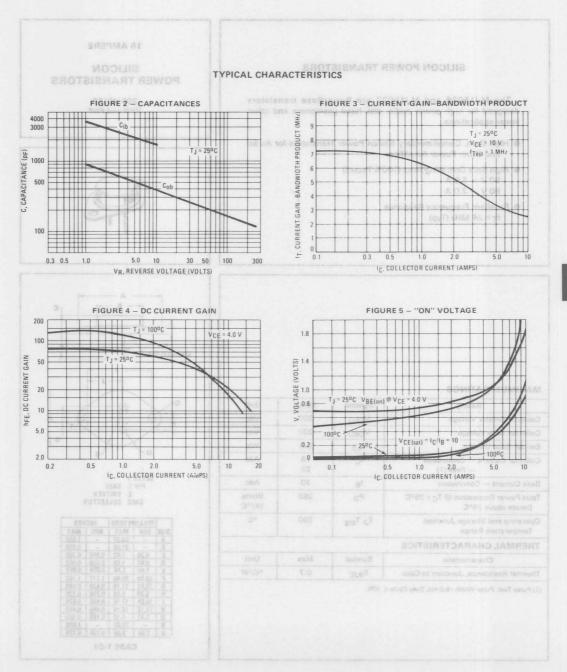




There are two limitations on the powerhandling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\mbox{\scriptsize C}} \sim V_{\mbox{\scriptsize CE}}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{JI(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.







# SILICON POWER TRANSISTORS

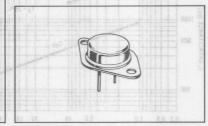
The MJ15026 and MJ15027 are PowerBase transistors designed for high power audio, disk head positioners and other linear applications.

- High Gain, Complimentary Silicon Power Transistors for Audio and Other Power Amplifiers
- High Safe Operating Area (100% Tested)
   50 V 5.0 A
   80 V 2.0 A
- Excellent Frequency Response f<sub>T</sub> = 24 MHz (Typ)

16 AMPERE

# SILICON POWER TRANSISTORS

200 VOLTS NPN and PNP



3

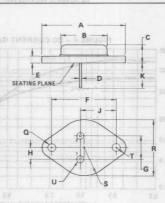
# MAXIMUM RATINGS Rating Symbol Value Unit Collector-Emitter Voltage VCEO 200 Vdc Collector-Base Voltage VCRO 200 Vdc

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	200	Vdc
Collector-Base Voltage	VCBO	200	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous — Peak (1)	lc	16 32	Adc
Base Current — Continuous	IB	70	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	250	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	200	°C

Temperature Range
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit		
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W		

(1) Pulse Test: Pulse Width =5.0 ms, Duty Cycle ≤ 10%.



STYLE 1
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

	MILLIN	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	-	39.37	-	1,550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
Н	5.33	5.59	0.210	0.220	
J	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1.050	
U	2.54	3.05	0.100	0.120	

CASE 1-04

ELECTRICAL	CHARACTERISTICS	(T <sub>C</sub> = 25°C unless otherwise noted)
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Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		VPN	M115026	
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 20 mA, I <sub>B</sub> = 0)	VCEO(sus)	200 MIAD MAR	IE 2 — QC CUR	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 200 Vdc, V <sub>BE</sub> (off) = 1.5 Vdc)	ICEX		1.0	mA
Collector Cutoff Current (VCE = 120 Vdc, I <sub>B</sub> = 0)	CEO		1.0	mA
Emitter Cutoff Current (VCE = 5.0 V, IB = 0)	IEBO		1.0	mA
SECOND BREAKDOWN			V 0.8 = 30V	
Second Breakdown Collector Current with Base Forward-Biased (VCE = 50 Vdc, t = 0.5 s (non-repetitive)) (VCE = 80 Vdc, t = 0.5 s (non-repetitive))	IS/b — —	5.0 2.0	25°C     25°	Adc
*ON CHARACTERISTICS				
DC Current Gain (1	hee of	25 6.0	150	102 - 01
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 0.5 Adc) I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 4.0 Adc)	VCE(sat)	DBR W <u>OL</u> TARUS	1.0	Vdc PGURE 4 — 0
Base-Emitter On Voltage (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	VBE(sat)	THE THEFT	2.0	Vdc
DYNAMIC CHARACTERISTICS	25-6	JI AIII		
Current-Gain — Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	fŢ	15	1-1-11	MHz
Output Capacitance	Coh	ALC: N	750	pF

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%

(V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f<sub>test</sub> = 1.0 MHz)

# FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



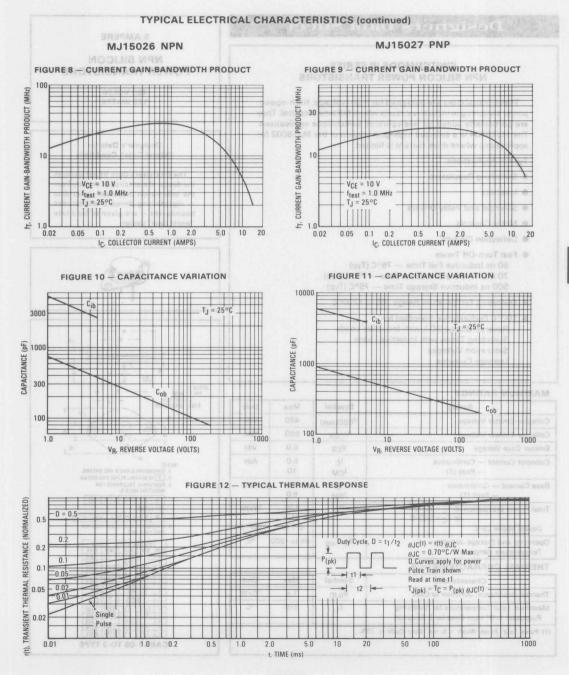
There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>—V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

MITSO26 NPN, MITSO27 PNP

The data of Figure 1 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

IC. COLLECTOR CURRENT (AMPS)

IC, COLLECTOR CURRENT (AMPS)



# SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications. The MJ16004 is a selected high-gain version of the MJ16002 for applications where drive current is limited.

Typical Applications:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times 50 ns Inductive Fall Time — 75°C (Typ) 70 ns Inductive Crossover Time - 75°C (Typ) 500 ns Inductive Storage Time — 75°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents

# MAXIMUM RATINGS

Rating	Symbol	Max	Unit
Collector-Emitter Voltage	VCEO(sus)	450	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage (87.00) SHADOV SARSVAR AV	VEB	6.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	5.0 10	Adc
Base Current — Continuous — Peak (1)	IBM	8.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	125 71.5 0.714	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

# THERMAL CHARACTERISTICS

I have been been been	
1.4	°C/W
275	°C
1	

5 AMPERE

MPN

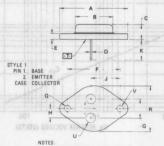
# **NPN SILICON** POWER TRANSISTORS

450 VOLTS 125 WATTS

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case" design.





- DIMENSIONS O AND V ARE DATUMS
- T. IS SEATING PLANE AND DATUM.
  POSITIONAL TOLERANCE FOR MOUNTING HOLE Q:
- ♦ 13 (0.005) · T V ·
- ♦ \$.13 (0.005) ⊗ T V ⋈ Q ⋈ 4. DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973.

	MILLIA	METERS	INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	1	39.37	-	1,550	
В		21.08	1-1	0.830	
C	6.35	7.62	0.250	0,300	
D	0.97	1.09	0.038	0.043	
E	1.40	1.78	0.055	0.070	
F	30.15	BSC	1,187 BSC		
G	10.92	2 BSC	0.430 BSC		
Н	5.48	BSC	0.215 BSC		
1	16.89	BSC	0.669	BSC	
K	11.18	12.19	0.440	0.480	
0	3.81	4.19	0.150	0.165	
R	-	26.67	-	1,050	
U	4.83	5.33	0.190	0.210	
٧	3.81	4.19	0.150	0.165	

CASE 1-05 TO-3 TYPE

# MJ16002

transcription of the	Characteristic			Symbol	Min	Тур	Max	Unit
				7,		170	Legittera	roadano:
OFF CHARACTER	ISTICS (1)	460	VegegganV		12)	Voltage (Table	Sustaining	scior-Emitter
(I <sub>C</sub> = 100 mA, I <sub>B</sub> =	ustaining Voltage (Table = 0)	2)		VCEO(sus)	450	-	#0 = g	Am Vdc = 5
	VBE(off) = 1.5 Vdc) VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)	g a d	ICEV	10000)	= 1.5 Vda) = 1.5 <del>V</del> da, T <sub>C</sub>	0.25 1.5	OmAdc
Collector Cutoff Cur (VCF = 850 Vdc, F	rent RBE = 50 Ω, T <sub>C</sub> = 100°C)		nami.	ICER	- 1	n. T <sub>C</sub> =100°C	08 2.5	mAdc
Emitter Cutoff Curre (VEB = 6.0 Vdc, Ic	ent		Clear	IEBO	-	-	(1.0 )	mAdc
SECOND BREAKE	OOWN		1	boasis bu			ver Celleray	ushdeand how
Second Breakdown	Collector Current with E	Base Forwa	ard Biased	IS/b	Sure of	See Figure 15		on head bane
	SOA with Base Reverse		MOSEN	RBSOA	Basard I	See Figure 16	BIN AUG 61	aradoni pedu
						30.010	1) 2017218	CHARACTE
ON CHARACTERI			Vectory			Voltage	Saturation	ector-Emitte
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = (I <sub>C</sub> = 3.0 Adc, I <sub>C</sub> = (I <sub>C</sub>	0.2 Adc)			VCE(sat)	=	() T <sub>C</sub> = ±00°C)	1.0 2.5 2.5	= 3.0 Adc. = 3.0 Adc. = 3.0 Adc.
Base-Emitter Satura			VBEfeat)	V <sub>BE(sat)</sub>		201	a = 0.3 Add	Vdc
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> =				- DE(Sat)		(0°0 <del>01</del> = 0T	ob	obA 0.E =
DC Current Gain				hFE	5.0	- 5	N D.8- 30 N	= 5-0 Adc.
						3011	PIRITOAR	THO DIMAN
DYNAMIC CHARA	OUS TO THE REAL PROPERTY OF THE PERTY OF THE	100	Cob				501	aut Capacillar
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub>	= 0, f <sub>test</sub> = 1.0 kHz)			C <sub>ob</sub>	-	(SH# 0.1 =	200	DBV OpF- 80
SWITCHING CHAI	RACTERISTICS						17 -14-7	Lbsc.Lavite
Resistive Load (Tab	ole 1)	-					T Block	- USES SVINE
Delay Time	000 001		- b/	t <sub>dsbA</sub> 8	) s yeel)	30	100	ns
Rise Time	(I <sub>C</sub> = 3.0 Adc,	(IR2 = 0	).8 Adc,	t <sub>r</sub> (0.0)	1 = c <del>ut</del> 3	100	300	age Time
Storage Time	V <sub>CC</sub> = 250 Vdc,		3.0 Ω)	ts	- 780	1000	3000	emil emil
Fall Time	I <sub>B1</sub> = 0.4 Adc,		-1	tf		60	300	ege Time
Storage Time	PW = 30 μs,		n old	ts	to)as <u>V</u> )	400	Dury C	amil aga
Fall Time	Duty Cycle ≤2.0%)	(VBE(of	f) = 5.0 Vdc)	tf	-	130	15 A10-Y	han Levita
Inductive Load (Tal	ble 2)						12 61351	0.007
Storage Time	087 08		20	t <sub>sv</sub> (0°0)	1	500	1600	ns
Fall Time	(Ic = 3.0 Adc,	(T <sub>.</sub> J = 10	00°C)	tfi	11 41.11)	100	200	sover Time
Crossover Time	I <sub>B1</sub> = 0.4 Adc,			t <sub>C</sub>		120	250	sover since
Storage Time	V <sub>BE(off)</sub> = 5.0 Vdc,		201	t <sub>sv</sub> (300	t meth	600	MACKET !	Time
Fall Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>.1</sub> = 15	50°C)	tfi		120	- 1	saver Time
Crossover Time	CL(pk)			t <sub>C</sub>		160		U/10/ 10/902

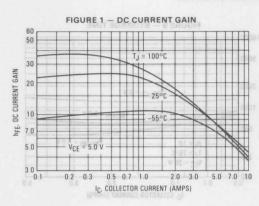
<sup>\*</sup> $\beta_f = \frac{I_C}{I_{B1}}$ 

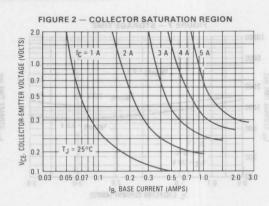
# MJ16004

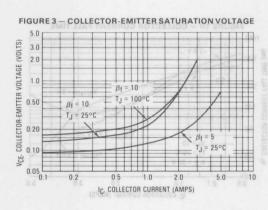
FLECTRICAL	CHARACTERISTICS	(Tc = 25°C unless otherwise noted)

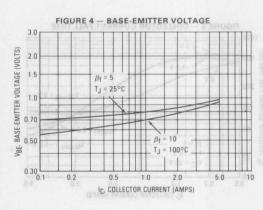
Characteristic			Symbol	Min	Тур	Max	Unit	
OFF CHARACTERISTICS (1)	dål	nine	Sympol			oldsheltonial	0	
Collector-Emitter Sustaining Vol	tage (Table	2)		V <sub>CEO(sus)</sub>	450	_ (1	ENISTICS (	Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub> = 0)				020(000)	12)	Voltage (Table		ettim E-totae
Collector Cutoff Current				ICEV			(0 × V)	mAdc
(VCEV = 850 Vdc, VBE(off) = 1.	5 Vdc)			024	-	_	0.25	Hotel Cutoff
(VCEV = 850 Vdc, VBE(off) = 1.5 Vdc, TC =		100°C)			-	156 <del>91</del> 8.1 =	1.5	DEV = 850 V
Collector Cutoff Current	T. C.			ICER	(D)(001)	01.36 <u>V</u> 6.10	2.5	mAdc
(V <sub>CE</sub> = 850 Vdc, R <sub>BE</sub> = 50 Ω, T	C = 100°C)		REOF					etar Curoff
Emitter Cutoff Current				IEBO		D-001 = 51 .fl	1.0	mAdc
(V <sub>EB</sub> = 6.0 Vdc, I <sub>C</sub> = 0)			083					tar Curoff C
SECOND BREAKDOWN							10 = 31 .	30 V C 8 = 83
Second Breakdown Collector Current with Base Forward Biased				IS/b	See Figure 15			
Clamped Inductive SOA with Base Reverse Biased			g S <sub>1</sub>	RBSOA	See Figure 16			
RESDA   See Figure 16			become several area on w AOZ symmen team					
ON CHARACTERISTICS (1)							NETICS (	ITD A.RES
Collector-Emitter Saturation Vol	tage			VCE(sat)				Vdc
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 0.15 Adc)						- SHOV	1.0	ctor-Emilte = 1 b Adc. I
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.3 Adc) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.3 Adc, T <sub>C</sub>	= 100°C)						2.5	= 3.0 Adc. I
Base-Emitter Saturation Voltage			Vari	-	10 = 100 = 31	38A ₽.0 ≥ g	Vdc	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.3 Adc) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 0.3 Adc, T <sub>C</sub> = 100°C)				V <sub>BE(sat)</sub>		- 000	105 mg	1
					_	_	1.5	= 3.0 Adc.
DC Current Gain	100	14000		hFF	7.0	10°001 = 51	8 - 0.4 Ade	= 3,0 Adc.
(IC = 5.0 Adc, VCF = 5.0 Vdc								ureni Gan
DYNAMIC CHARACTERISTIC	s					3	M D S = BD A	= 5.0 Adc.
Output Capacitance				Cob		TICS	200	DF OF
(V <sub>CB</sub> = 10 Vdc, I <sub>F</sub> = 0, f <sub>test</sub> = 1.0 kHz)				000			800	at Capacita
SWITCHING CHARACTERISTICS						(sHs 0.1 =	Ig = 0, figgs	96V 07 = 80
Resistive Load (Table 1)						STICS	MARACTER	10 SMB01
Delay Time						30	100	ns ns
Rise Time (IC = 3.0 A)	Fime $(I_C = 3.0 \text{ Adc}, (I_B = 250 \text{ Vdc}, I_B = 0.3 \text{ Adc}, I_B = 0.3 \text{ Adc}, I_B = 0.3 \text{ Adc}, I_B = 0.0 \text{ PW} = 30 \mu\text{s}, I_B = 0.0 \text{ PW}$		).6 Adc,	t <sub>d</sub>		130	300	ns amil v
Storage Time VCC = 250			3.0 Ω)	t <sub>S</sub> MA 8	(0 = c <del>al</del> )	800	2700	Time
Fall Time			i j	t <sub>f</sub> (n 0	3 × c=9	80	350	anilT egi
Storage Time PW = 30 µ:			50/44	ts	_	250	10	Firme
Fall Time Duty Cycle			(VBE(off) = 5.0 Vdc)		Clare, e	60	Outuro)	ige Time
Inductive Load (Table 2)	130		1 1	1307-0-1	Hurjahi V	200		91/11
Storage Time				t <sub>sv</sub>		400	1300	ns
Fall Time (I <sub>C</sub> = 3.0 A	dc,	(T <sub>.1</sub> = 1	00°C)	tfi		80	150	emil egr
Crossover Time IB1 = 0.3 A	dc,	11.5		t <sub>c</sub> O°0	3/ = <del>  I</del>	90	200	Time
Storage Time VBE(off) =	me VBE(off) = 5.0 Vdc,		- 1			450	0 = (=1	sover Time
Fall Time VCE(pk) = 400 Vdc)		(T <sub>J</sub> = 150°C)		t <sub>sv</sub>	-	100	Hold B	emil apr
Crossover Time			- 10		81 = L1)	110	Velick	emil

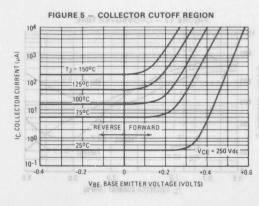
# TYPICAL STATIC CHARACTERISTICS

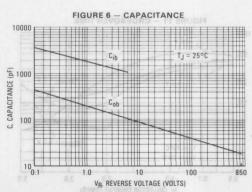




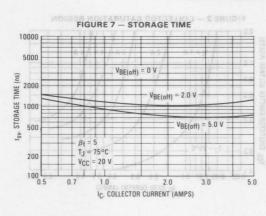


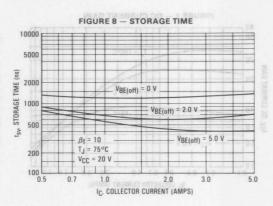


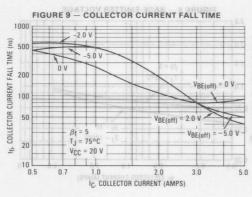


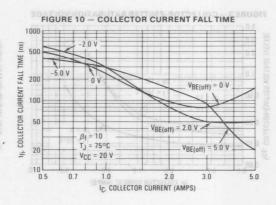


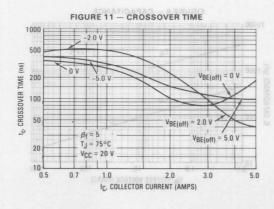
### TYPICAL DYNAMIC CHARACTERISTICS











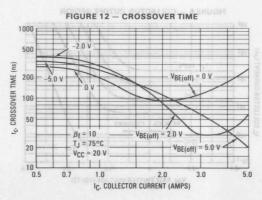




FIGURE 13 - INDUCTIVE SWITCHING MEASUREMENTS

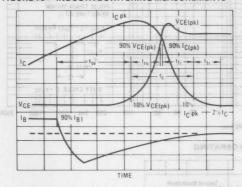
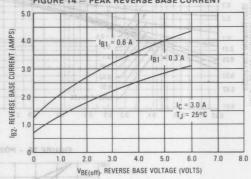


FIGURE 14 - PEAK REVERSE BASE CURRENT



#### **GUARANTEED SAFE OPERATING AREA LIMITS**

FIGURE 15 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA

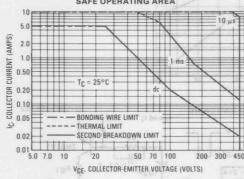
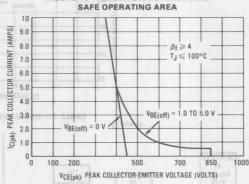


FIGURE 16 - MAXIMUM REVERSE BIAS



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\text{C}}$ — $V_{\text{CE}}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 15 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

 $T_{J(pk)}$  may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will reduce

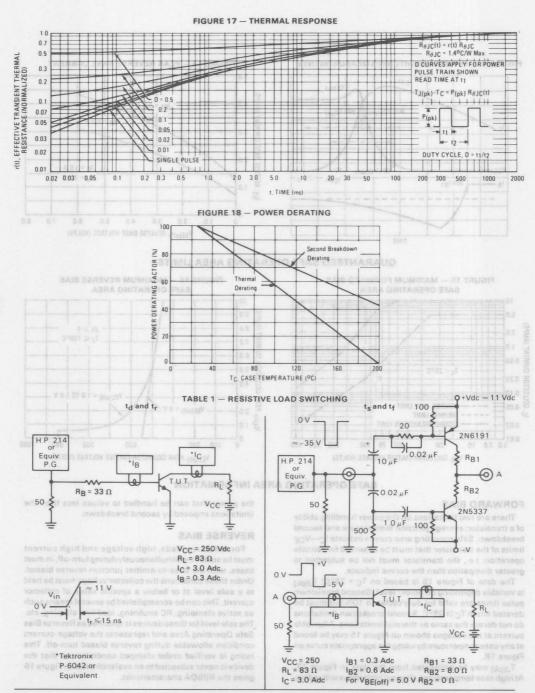
the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

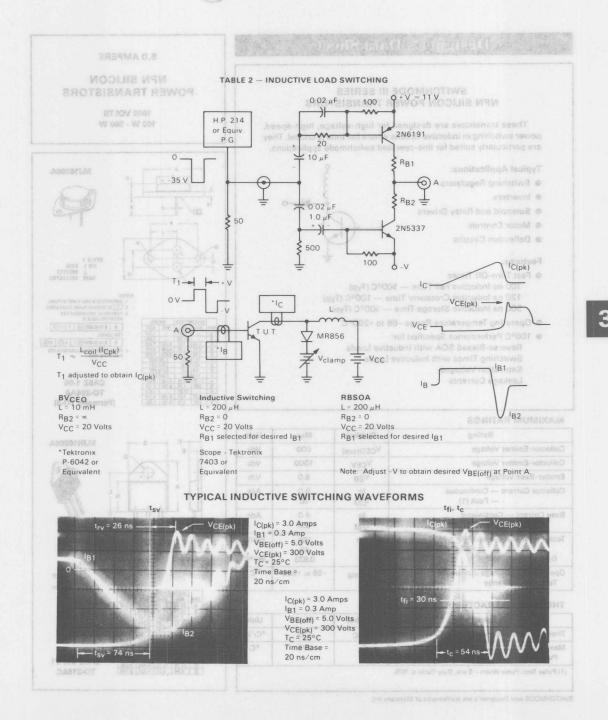
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.

3





\*Note: Adjust -V to obtain desired VBE(off) at Point A.





# Designer's Data Sheet

## **SWITCHMODE III SERIES** NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

#### **Typical Applications:**

- Switching Regulators
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

## Features:

- Fast Turn-Off Times 100 ns Inductive Fall Time - 100°C (Typ) 120 ns Inductive Crossover Time — 100°C (Typ) 500 ns Inductive Storage Time — 100°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages Leakage Currents

#### **MAXIMUM RATINGS**

Rating right between 101	Symbol	Max	Unit
Collector-Emitter Voltage	VCEO(sus)	500	Vdc
Collector-Emitter Voltage	VCEV	1000	Vdc
Emitter-Base Voltage	VEB	6.0	Vdc
Collector Current — Continuous — Peak (1)	BVICM DV	10 5.0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	4.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	100 40 0.833	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	o °C

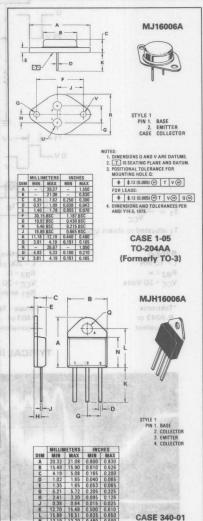
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.25	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

#### 5.0 AMPERE

## **NPN SILICON POWER TRANSISTORS**

1000 VOLTS 100 W - 500 W

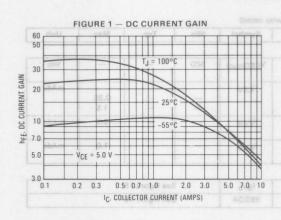


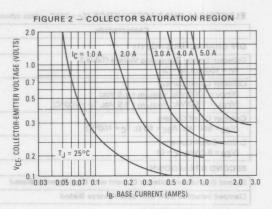
TO-218AC

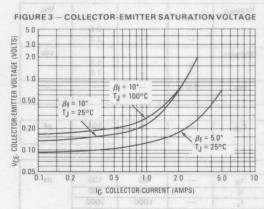
# TYPICAL STAASOOBLUM TERISTICS

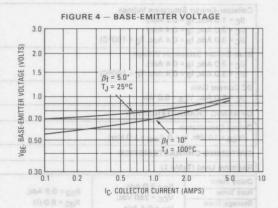
	Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTE	RISTICS (1)							Ut
Collector-Emitter S	Sustaining Voltage (Table = 0)	e 2) (c.f. w	VCEO(sus)	500	1000 T <u>11</u>	+	Vdc	08
	urrent dc, VBE(off) = 1.5 Vdc) dc, VBE(off) = 1.5 Vdc, T <sub>C</sub>	;= 100°C)	ICEV	-/-	28	0.25 1.5	mAdo	es
Collector Cutoff Cu (VCE = 850 Vdc,	rrent R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C	( so #	CER	G-T	°28-	2.5	mAdo	0
Emitter Cutoff Cur (V <sub>EB</sub> = 6.0 Vdc, I		B 02 TJ = 25°C	IEBO	-		1.0 V 0.8 = 30	mAdo	0
SECOND BREAK	DOWN	HIII E	MILE					
Second Breakdow	n Collector Current with	Base Forward Biased	IIS/b	20 30	See Figure 1	58.0 8.0 1	0 1	0
Clamped Inductive	SOA with Base Reverse	Biased	RBSOA	LAMPS	See Figure 1	6100.01		
ON CHARACTER						No. of the last of		
Collector-Emitter S	Saturation Voltage = 0.2 Adc)	FIGURE	VCE(sat)	MOIT <u>A</u> RUT	MITTER SA	1.0	Vdc 0 - 8 ar	11)
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub>	= 0.4 Adc) = 0.4 Adc, T <sub>C</sub> = 100°C)	3.0		_	FILE	2.5		
Base-Emitter Satu (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub>		20	VBE(sat)	7		1.5	Vdc	0.
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>C</sub>	e <sub>E</sub> = 5.0 Vdc	D.T ASSET	hFE	5.0	0.001 = - 101 =			03
DYNAMIC CHAR	ACTERISTICS	nt n S		VII	NU	25°0	V I	
Output Capacitano (V <sub>CB</sub> = 10 Vdc, I	e E = 0, f <sub>test</sub> = 1.0 kHz)	8 0.50	C <sub>ob</sub>	- 18 - X		200	pF	88
SWITCHING CHA	RACTERISTICS		199	S F VI			-	01
Resistive Load (Ta	ible 1)	00.0						
Delay Time	U - 20 Ad-	26 10	of t <sub>d</sub>	_ 9.5	30	100	0 ns	0
Rise Time	(I <sub>C</sub> = 3.0 Adc, V <sub>CC</sub> = 250 Vdc,	(I <sub>B2</sub> = 0.8 Adc,	t <sub>r</sub>	(AMP=+	100	300		
Storage Time	I <sub>B1</sub> = 0.4 Adc,	$R_{B2} = 8.0 \Omega$ )	ts	-	1000	3000		
all Time	PW = 30 μs,	hi	tf	-	60	300	100	
Storage Time		(VBE(off) = 5.0 Vdc)	t <sub>S</sub>	OFF. REGIO	400	ES = COU	FIGUR	
all Time		DEPART DORGE	tf	C SIS	130		-	hg
nductive Load (Ta	able 2)		111	11/		T		
Storage Time		T 10000	t <sub>sv</sub>	7-7	500	1600	ns	
all Time	(I <sub>C</sub> = 3.0 Adc,	(T <sub>J</sub> = 100°C)	tfi	177	100	200	7	
Crossover Time Storage Time	IB1 = 0.4 Adc,	\$ 1000 E	t <sub>C</sub>	1	120 600	250		
all Time	VBE(off) = 5.0 Vdc,	(T 1500C)	tsv	7.7	120	3-651		
Crossover Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>J</sub> = 150°C)	t <sub>fi</sub>	1	160	1000		
1) Pulse Test: PW - 3	300 μs, Duty Cycle ≤2%.	001 &			UNAWROT	aznavan		La
			- 250 Vdc -	NOV NO		208	1	

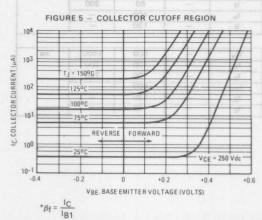
#### TYPICAL STATIC CHARACTERISTICS

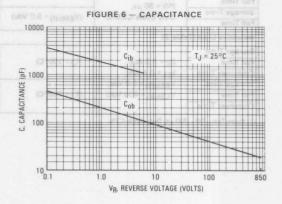




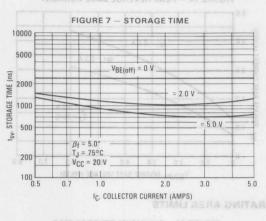


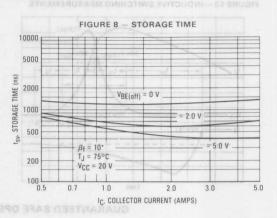


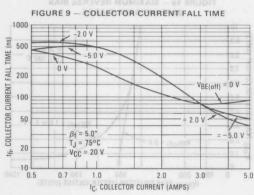


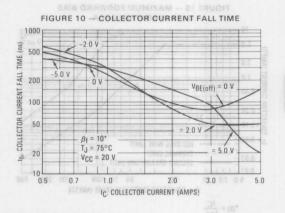


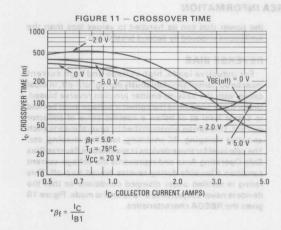
#### TYPICAL DYNAMIC CHARACTERISTICS











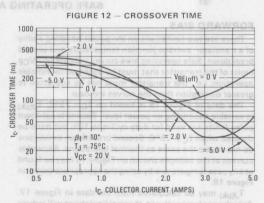


FIGURE 13 - INDUCTIVE SWITCHING MEASUREMENTS

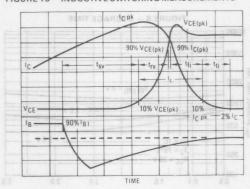
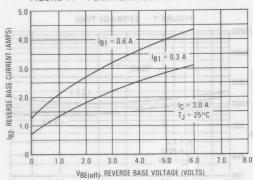


FIGURE 14 - PEAK REVERSE BASE CURRENT



#### **GUARANTEED SAFE OPERATING AREA LIMITS**

FIGURE 15 — MAXIMUM FORWARD BIAS

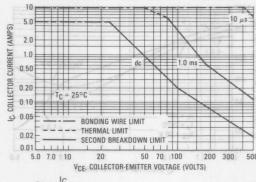
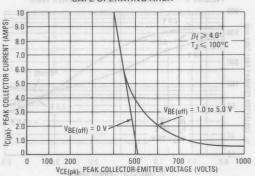


FIGURE 16 — MAXIMUM REVERSE BIAS
SAFE OPERATING AREA



\* $\beta_f = \frac{I_C}{I_{B1}}$ 

## SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C\!-\!V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 15 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

T<sub>J(pk)</sub> may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will reduce

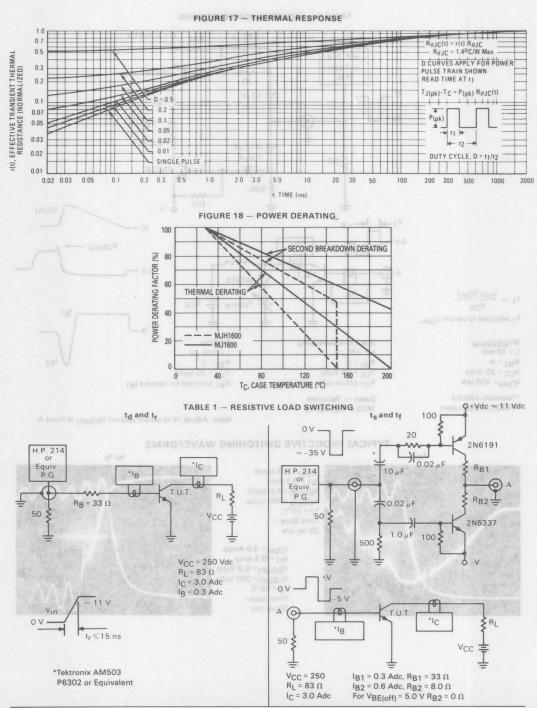
the power that can be handled to values less than the limitations imposed by second breakdown.

## **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.

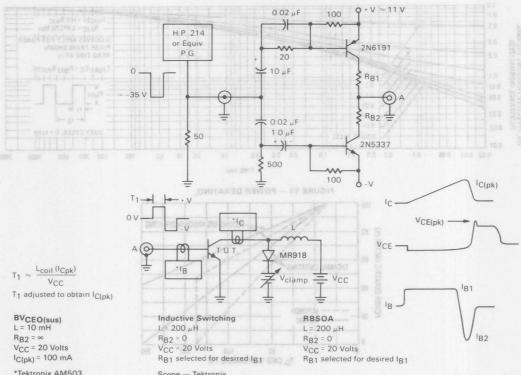
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Note: Adjust -V to obtain desired VBE(off) at Point A.

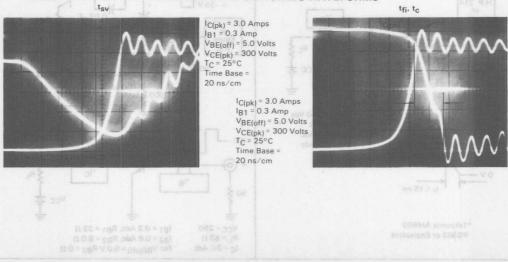
#### TABLE 2 - INDUCTIVE LOAD SWITCHING



\*Tektronix AM503 P6302 or Equivalent Scope — Tektronix 7403 or Equivalent

Note: Adjust -V to obtain desired VBE(off) at Point A.

#### TYPICAL INDUCTIVE SWITCHING WAVEFORMS





MJ16006 MJ16008 MJH16006 MJH16008

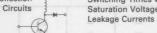
# Designer's Data Sheet

# SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications. The MJ16008 and MJH16008 are selected high gain versions of the MJ16006 and MJH16006 for applications where drive current is limited.

Typical Applications: Features:

- Switching Regulators
- Fast Turn-Off Times
- 70 ns Inductive Fall Time 100°C (Typ)
  100 ns Inductive Crossover Time 100°C (Typ)
  500 ns Inductive Storage Time 100°C (Typ)
- InvertersSolenoidsRelay Drivers
- 100°C Performance Specified for:
- Reverse-Biased SOA with Inductive Load Switching Times with Inductive Loads Saturation Voltages



#### **MAXIMUM RATINGS**

Rating 3.1	Symbol	MJ16006 MJ16008	MJH16006 MJH16008	Unit
Collector-Emitter Voltage	VCEO(sus)	0.8 4!	50	Vdc
Collector-Emitter Voltage	VCEV	8!	50	Vdc
Emitter-Base Voltage	VEB	6	.0	Vdc
Collector Current  — Continuous  — Peak (1)	I <sub>C</sub>	8	.0	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		.0	Adc
Total Device Dissipation  @ T <sub>C</sub> = 25°C  @ T <sub>C</sub> = 100°C  Derate above 25°C	07 006	150 85.5 0.86	125 50 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	TJ,T <sub>stg</sub>	-65 to 200	-55 to 150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Ma	ax	Unit
Thermal Resistance, Junction to Case	R <sub>Ø</sub> JC	1.17	1.0	°C/W
Lead Temperature for Soldering Purposes, 1/8" from Case for 5 Seconds.	TL	27	5	°C

(1) Pulse Test: Pulse Width ≤ 5.0 µs, Duty Cycle ≥ 10%.

#### Designer's Data for "Worst Case" Conditions

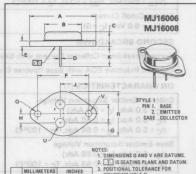
The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit Curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

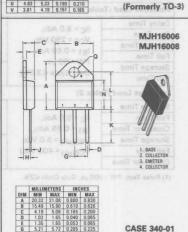
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# 8.0 AMPERE

# NPN SILICON POWER TRANSISTORS

450 VOLTS 125 AND 150 WATTS





TO-218AC







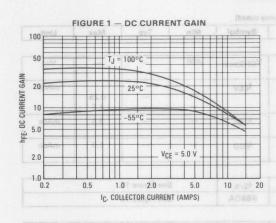
## MJ16006 MJH16006

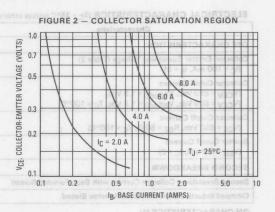
38397	Characteristic	produce and the second second	Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS (1)		8365	36 18 300	SWITCHMA	1	
Collector-Emitter S (I <sub>C</sub> = 100 mA, I <sub>B</sub>	ustaining Voltage (Table 2 = 0)	beegs-doit	VCEO(sus)	450	ILICO <u>I</u> N PO	N <u>P</u> N S	Vdc
Collector Cutoff Cu (V <sub>CEV</sub> = 850 Vdc		a de cretcal. Higgs ebon de gain gain ver-	CEV	oncelts with the coperation of	avitaubni i by sulted fo LM sed MJ	0.25	mAdc
Collector Cutoff Cu		where drive	ICER	8 101 <u>8</u> 0001)	KUM <u>b</u> ns ac	2.5	mAdc
Emitter Cutoff Curr (VEB = 6.0 Vdc, I			IEBO	earnit fiQ-	Fest <u>ur</u> es: © Fast Turn	1.0	mAdc
SECOND BREAK	DOWN	- 100°C (Tura)	June - 100	indecays Fa	30 001	STOTEL	alvavni e
Second Breakdown	Collector Current with Ba	se Forward Biased	Is/b	1	See Figure 15		● Selane
Clamped Inductive	SOA with Base Reverse B	iased	RBSOA	formance S	See Figure 16	Ballovino	* Kelay I
ON CHARACTER	ISTICS (1)	Beal av	th industries t	by semiT pn	Switchi	2 10	9 Deflect
Collector-Emitter S (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 10.0 Adc, I <sub>B</sub>	= 0.4 Adc)		V <sub>CE(sat)</sub>	ion Voltages Curronts	Serviel Leskeg	2.5 3.0 3.0	Vdc
Base-Emitter Satur	ation Voltage		V <sub>BE(sat)</sub>			ATINGS	Vdc
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> =	= 0.66 Adc) = 0.66 Adc, T <sub>C</sub> = 100°C)	Minegos Unit		MITTERS	lottiny8	1.5 1.5	politeRi
DC Current Gain (I <sub>C</sub> = 8.0 Adc, V <sub>C</sub>	E = 5.0 Vdc	Vdc	hFE	5.0	faue)080V	enstioV re	Heptor-Emits
DYNAMIC CHAR	ACTERISTICS		0.8				
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub>	e = 0, f <sub>test</sub> = 1.0 kHz)	Ada	C <sub>ob</sub>	-	-	350	PF Curri
SWITCHING CHA	RACTERISTICS		16		ICM		- Pesk (1)
Resistive Load (Ta	ble 1)	Adc					se Current
Delay Time	(I <sub>C</sub> = 5.0 Adc,		td	-	20	50	ns
Rise Time	VCC = 250 Vdc,	(I <sub>B2</sub> = 1.3 Adc,	tr		85	250	(1) 8000
Storage Time	I <sub>B1</sub> = 0.66 Adc,	$R_{B2} = 4.0 \Omega$	ts	031	1000	2500	tal Device D @ To = 2
Fall Time	PW = 30 μs,	08	tf	3.08	70	250	@ Tc = 1
Storage Time Fall Time	Duty Cycle ≤2.0%)	(VBE(off) = 5.0 Vdc)	ts	98.Q	100	26%	Derete above
13.20	hla 21	150 150 00	tf	D of 80	100	egmetë	bna gnilates
Inductive Load (Ta	ble Z)				700	1800	Junction Ten
Storage Time Fall Time	11 - 5004	(T = 10000)	t <sub>sv</sub>		80	200	ns
Crossover Time	(I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 0.66 Adc,	(T <sub>J</sub> = 100°C)	tfi		150	250	IERMAL CE
Storage Time	V <sub>BE(off)</sub> = 5.0 Vdc,	tint3	tc		800	250	Charucter
Fall Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>J</sub> = 150°C)	t <sub>SV</sub>	1.17	80	_eone	ermal Resist
Crossover Time	CE(pk) 400 (dc)	1.3 100 0	t <sub>C</sub>	_	200	680	Junction to
(1) Pulse Test: PW - 3	00 μs, Duty Cycle ≤2%.	0-	212		1		ad Temperat Soldering Pu 1/8" from Cas 5 Seconds.
				.2°01 ≤ elo	io ps. Buty Cy		Pulse Test: Pu
			Conditions		ser's Data for	Dealgi	

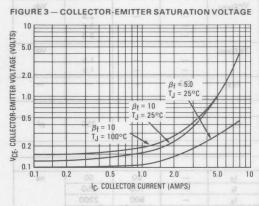
# MJ16008 ATRIBATO AMJH16008

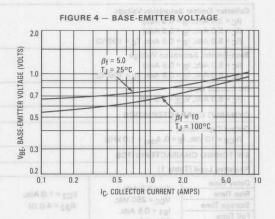
	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS						
	ustaining Voltage (Table	2)	V <sub>CEO(sus)</sub>	450	_0°851		Vdç
	rrent , VBE(off) = 1.5 Vdc) , VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)	ICEV		1º25	0.25 1.5	mAdc =
Collector Cutoff Cu (V <sub>CE</sub> = 850 Vdc, I	rrent R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	/1 1.8	ICER		30.90-	2.5	mAdc
emitter Cutoff Curr (VEB = 6.0 Vdc, I		ZIII sa	IEBO	V0.8 =	3V	1.0	mAdc
SECOND BREAK	DOWN	2					
econd Breakdown	Collector Current with	Base Forward Biased	OS IS/b OF	0.2	See Figure 1	5 20	0.2
	SOA with Base Reverse		RBSOA		See Figure 1		
ON CHARACTER							
Collector-Emitter S (IC = 3.0 Adc, IB =	aturation Voltage	riauai?	VCE(sat)	TURATION	EMIT <u>T</u> ER S	2.5	Vdc
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> =	= 0.5 Adc) = 0.5 Adc, T <sub>C</sub> = 100°C)	20		H=H	HI	3.0	01
(IC = 5.0 Adc, IB =			VBE(sat)			1.5 1.5	Vdc
OC Current Gain		100	hFE	7.0			- 0.3
DYNAMIC CHAR	X HILL			7	01=64年		
Output Capacitance		- La	Cob	AST	Z	350	pF
SWITCHING CHA	RACTERISTICS	180 8		N-X	ESPE		
Resistive Load (Ta	ble 1)	0.0					===
Delay Time	0.1 6.0	0.1 6.2	td Gd	_ 0.8	20	50	ns
lise Time	(I <sub>C</sub> = 5.0 Adc, V <sub>C</sub> C = 250 Vdc,	(I <sub>B2</sub> = 1.0 Adc,	t <sub>r</sub>	[2951A]	100	250	
torage Time	I <sub>B1</sub> = 0.5 Adc,	$R_{B2} = 4.0 \Omega$ )	ts	-	900	2200	
all Time	PW = 30 μs,		tf	_	70	250	
torage Time	Duty Cycle ≤2.0%)	(VBE(off) = 5.0 Vdc)	t <sub>s</sub>	OFF #EGIO	50	100 - 8 BF	UDIR
nductive Load (Ta	blo 2)	THE DAME	tf	<b>T</b>	50		I I I
	DIE 2)	102 NO.2	1111	1	F00	1400	
Storage Time	(I <sub>C</sub> = 5.0 Adc,	(T <sub>1</sub> = 100°C)	t <sub>sv</sub>	17.	500 70	1400	ns e
rossover Time	I <sub>R1</sub> = 0.5 Adc,	(1)-100 0/	tfi	1	100	200	
torage Time	VBE(off) = 5.0 Vdc,	HEB BALL	t <sub>C</sub>	1	600	200	7,1
all Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>J</sub> = 150°C)	t <sub>sv</sub>	7 3	100		1
rossover Time	CE(pk)	000 8	t <sub>C</sub>	1	150	- 3000L	
) Pulse Test: PW - 3	00 μs, Duty Cycle ≤2%.	007 €3	V 585 = 3	V 200	AMPROR -	- 98884	0.0

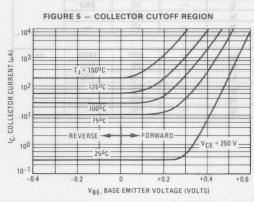
#### TYPICAL STATIC CHARACTERISTICS

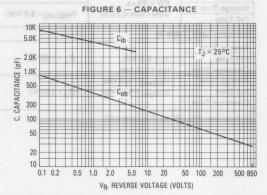






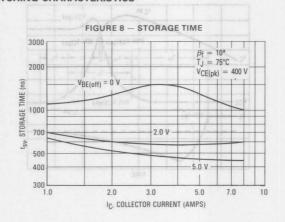


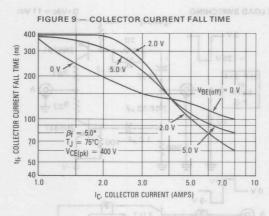


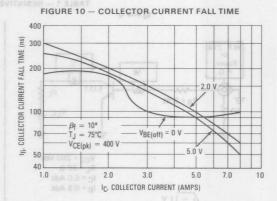


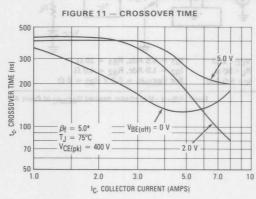
3

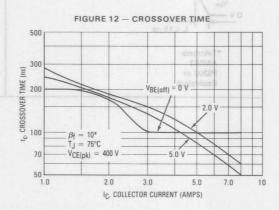
#### TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS FIGURE 7 - STORAGE TIME 3000 VBE(off) = 0 V 2000 STORAGE TIME (ns) 2.0 V 1000 700 5.0 V $\beta_{\rm f} = 5.0*$ T.I = 75°C 500 V<sub>CE(pk)</sub> = 400 V 400 300 1.0 3.0 5.0 7.0 10 I<sub>C</sub>, COLLECTOR CURRENT (AMPS)

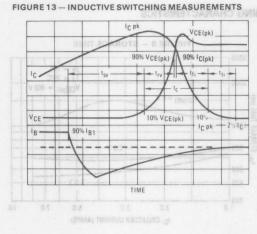


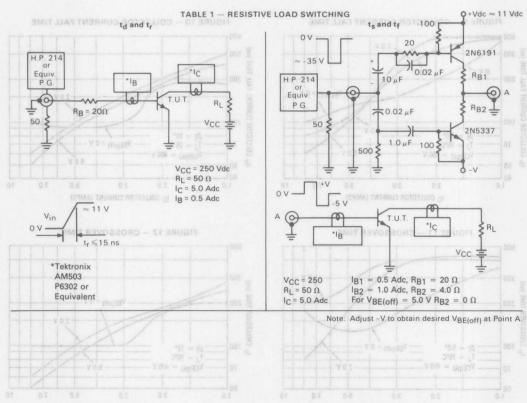




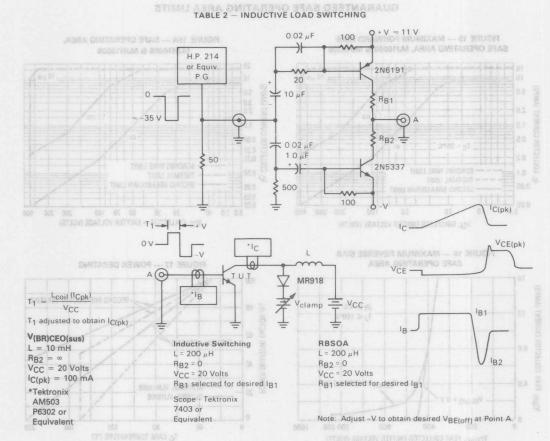








3



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C}-V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 15 and 15A are based on  $T_C=25^{\circ}\mathrm{C}$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geq 25^{\circ}\mathrm{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 and 15A may be found at any case temperature by using the appropriate curve on Figure 17.

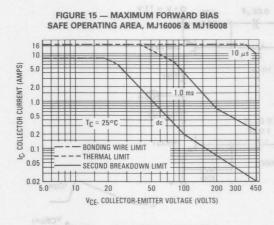
T<sub>J(pk)</sub> may be calculated from the data in Figure 18. At high case temperatures, thermal limitations will re-

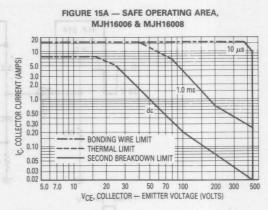
duce the power that can be handled to values less than the limitations imposed by second breakdown.

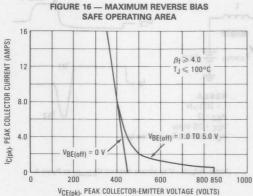
#### REVERSE BIAS

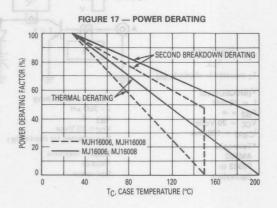
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.

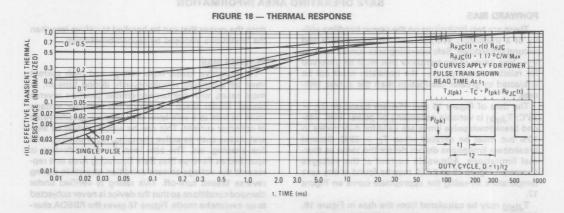
#### **GUARANTEED SAFE OPERATING AREA LIMITS**













# Designer's Data Sheet

# 1.0 kV SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications.

Typical Applications:

- Switching Regulators
- Inverters
- Solenoids
- Relay Drivers
- Motor Controls
   Deflection

Deflection
 Circuits

#### Features:

- Collector-Emitter Voltage
   VCEX = 1000 Vdc
- Fast Turn-Off Times
   80 ns Inductive Fall Time 100°C (Typ)
   120 ns Inductive Crossover Time 100°C (Typ)
   800 ns Inductive Storage Time 100°C (Typ)
- 100°C Performance Specified for: Reverse-Biased SOA with Inductive Load Switching Times with Inductive Loads Saturation Voltages Leakage currents



#### MAXIMUM RATINGS

IVIAAIIVIOIVI NATIIVOS		and the same of th		
Rating	Symbol	MJ16006A	MJH16006A	Unit
Collector-Emitter Voltage	VCEO(sus)	500		Vdc
Collector-Emitter Voltage	VCEV	10	000	Vdc
Emitter-Base Voltage	VEB	6	(VBE(on) 0.	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	8.0 16		Adc
Base Current — Continuous — Peak (1)	IBM		.0 2 507 = 17)	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	150	125	Watts
$@ T_C = 100^{\circ}C$ Derate above $T_C = 25^{\circ}C$	tel	85 0.86	50 1.0	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	-55 to 150	°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.17	1.0	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	27	75	°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

#### Designer's Data for "Worst Case" Conditions

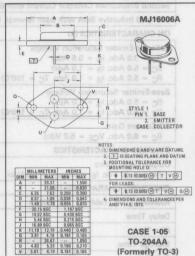
The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit Curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

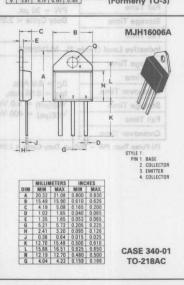
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#### 8.0 AMPERE

# NPN SILICON POWER TRANSISTORS

500 VOLTS 125 and 150 WATTS



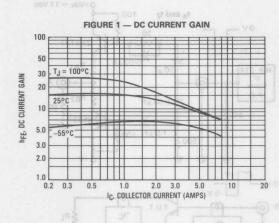


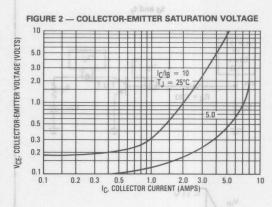
MJH16006A

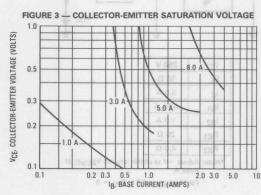


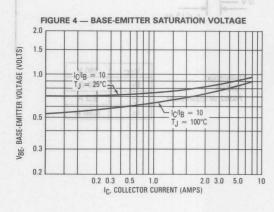
	Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTERIST	rics (1)	*****	Company of the Compan					San Mariana
Collector-Emitter Su (I <sub>C</sub> = 100 mA, I <sub>B</sub>	staining Voltage (Table 2) = 0)		13045	VCEO(sus)	500	1-16	10 - N	Vdc
	rent c, VBE(off) = 1.5 Vdc) c, VBE(off) = 1.5 Vdc, T <sub>C</sub>	= 100	)°C)	ICEV		=	0.25 1.5	mAdc
Collector Cutoff Cur (V <sub>CE</sub> = 1000 Vdc,	rent R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C	:)	SISTORS	ICER	ICON P	HS MAN	2.5	mAdc
Emitter Cutoff Curre (VEB = 6.0 Vdc, I			voltage, high spead,	IEBO	are dusig	enclaien	1.0	mAdo
SECOND BREAKDO	WN		Jone aboratorios he	cereme when	dvisousias	of the griffs	AN ANA W	adT
Second Breakdown	Collector Current with Ba	se For	ward Biased	IS/b		See F	igures 14	or 15
Clamped Inductive S	SOA with Base Reverse B	ased	THE RESERVE	RBSOA		Se	ee Figure	16
ON CHARACTERIST					Features	remonto	alquin las	HAL
Collector-Emitter Sa (IC = 3.0 Adc, IB (IC = 5.0 Adc, IB	= 0.6 Adc) = 1.0 Adc)		(qyT) 3°001 - amiT			_ =	1.0	Vdc
(IC = 5.0 Adc, IB Base-Emitter Satura (IC = 5.0 Adc, IB			sover Time - 100°C (Typ) age Time - 100°C (Typ) specified for:	V <sub>BE</sub> (sat)	#20 r 800 r 9 100°C	alor	1.5	Vdc
	= 1.0 Adc, $T_C = 100^{\circ}C$ )		V with inductive Load	Company Times	elvest.	-0	1.5	#G #
DC Current Gain (I <sub>C</sub> = 8.0 Adc, V <sub>C</sub>	E = 5.0 Vdc)		A CONTRACTOR OF THE CONTRACTOR	especial here des		1	-	-
DYNAMIC CHARAC	TERISTICS					101		
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>I</sub>	= 0, f <sub>test</sub> = 1.0 kHz)			C <sub>ob</sub>	-	1	350	pF
SWITCHING CHARA	CTERISTICS					N. C.		
Resistive Load (Tab	le 1) MJ16006A							
Delay Time	新教士 海朝   1	-		td		25	100	ns
Rise Time	(I <sub>C</sub> = 5.0 Adc,		(I <sub>B2</sub> = 1.3 Adc,	tr	_	400	700	JIVRXA
Storage Time	V <sub>CC</sub> = 250 Vdc,	ziel!	$R_{B2} = 4.0 \Omega$	ts	_	1400	3000	-
Fall Time	$I_{B1} = 0.66 \text{ Adc},$ $PW = 30 \mu s,$	Velo		tf	-	175	400	liector-
Storage Time	Duty Cycle ≤ 2.0%)	25/4	(Vas. 60 - 5.0 Vda)	ts		475	ny tomini	notoali
Fall Time	e 9   9	Vdc	(VBE(off) = 5.0 Vdc)	tf		100	Set Angeleic	B-tessio
Inductive Load (Tab	ole 2) MJ16006A	ShA	0.8	- DI	81,	Comingo	- mexita	J 10108H
Storage Time	HIVE		2.0	t <sub>sv</sub>	_	800	2000	ns
Fall Time		ob/A	$(T_J = 100^{\circ}C)$	tfi	_	80	200	11110, 83
Crossover Time	(I <sub>C</sub> = 5.0 Adc, I <sub>B1</sub> = 0.66 Adc,	Natte	180 128	tc	D*84 =	120	300	wo's lat
Storage Time	V <sub>BE(off)</sub> = 5.0 Vdc,		85 50	t <sub>sv</sub>	0.001 =	1000	_	
Fall Time	$V_{CE(pk)} = 400 \text{ Vdc}$	SUL	$(T_J = 150^{\circ}C)$ 89.0	tfi		90	OT sved	828180
Crossover Time		279	-65 to 200 - 55 to 150	t <sub>C</sub>	- 110	150	sofO bus	erating
7-1	300 μs, Duty Cycle ≤ 2.0%.			-			A DEALER	A A PROPERTY
24A5 1 APV 24A5 1 APV 252LLC2 C 271W/5 C	· · · · · · · · · · · · · · · · · · ·					CTERIST teristic		
	in teampoint							
	#048 X 2 1			11		or Solderli m Case fo	on) 181 tro	
								Pulse Te
			nditions	Worst Case" Ce	a Data for			
ANS CASE 340								

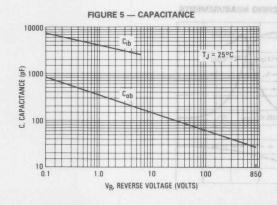
# TYPICAL STATIC CHARACTERISTICS

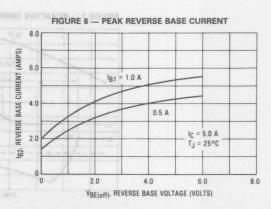




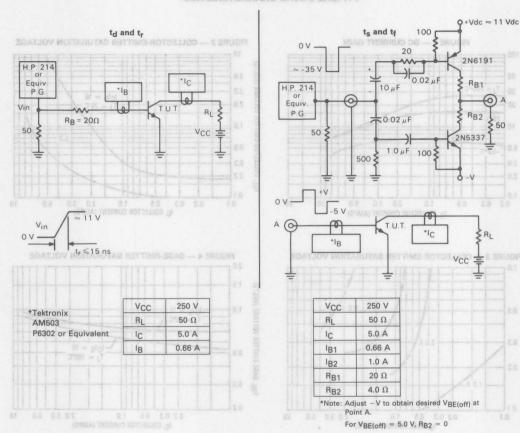




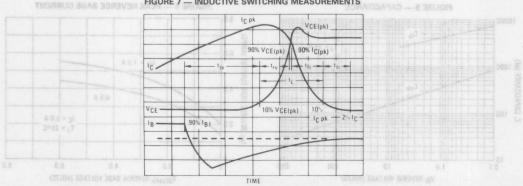




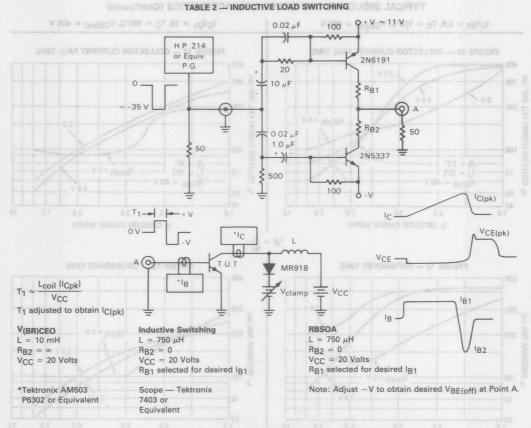
#### TABLE 1 — RESISTIVE LOAD SWITCHING



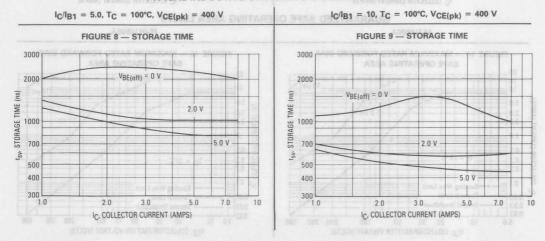




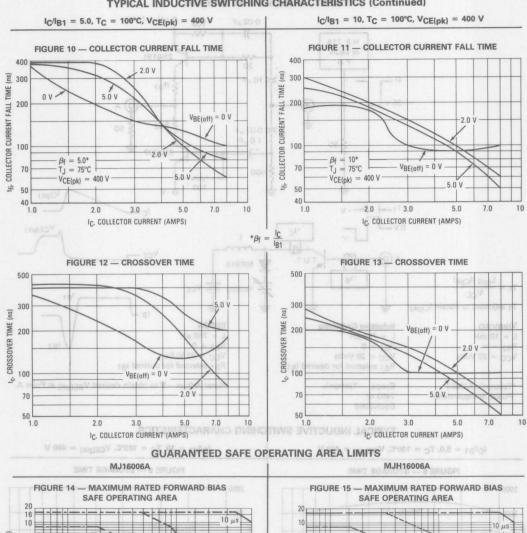


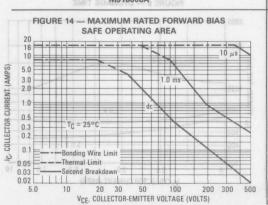


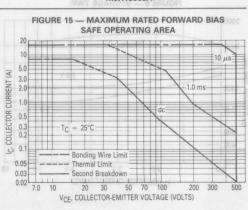
# TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS



#### TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS (Continued)

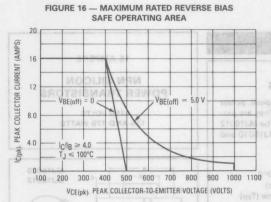


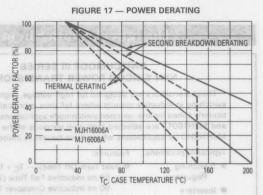




MOTOROLA

### **GUARANTEED SAFE OPERATING AREA LIMITS (Continued)**





# SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC — VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

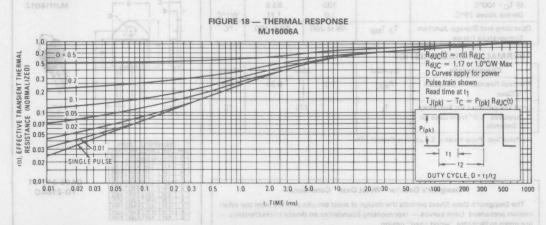
The data of Figures 14 and 15 are based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 14 and 15 may be found at any case temperature by using the appropriate curve on Figure 17.

T<sub>J(pk)</sub> may be calculated from the data in Figure 18. At high case temperatures, thermal limitations will re-

duce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable putting reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.



3

# Designer's Data Sheet

#### SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications. The MJ16012 and MJH16012 are selected high gain versions of the MJ16010 and MJH16010 for applications where drive current is limited.

Typical Applications:

- Features:
- Switching Regulators
- Inverters
- Solenoids
- Relay Drivers
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times T<sub>C</sub> = 100°C 50 ns Inductive Fall Time (Typ) 90 ns Inductive Crossover Time (Typ) 800 ns Inductive Storage Time (Typ)

PE DPERATING AREA LIMITS (Continued)

■ 100°C Performance Specified for: Reverse-Biased SOA with Inductive Loads Switching Times with Inductive Loads Saturation Voltages

Leakage Currents

-to-emitter junction reverse		MJ16010	MJH1601	0	
egatiov 10Ratingo edit angili	Symbol	MJ16012	MJH1601	2	Unit
Collector-Emitter Voltage	VCEO(sus)	4	50	06	Vdc
Collector-Emitter Voltage	VCEV	8	50	bine	Vdc
Emitter-Base Voltage	VEB	ipnigaria 6	6.0		Vdc
Collector Current — Continuous				ses	Adc
politica elderro- Peak (1)	CM	sents the vol	20		a yrus
Base Current — Continuous		seasid easek	10		Adc
Detasidus 19- Peak (1) vob urti		ibnos begmi			
Total Device Dissipation	PD	rionels vs as	07	EF	Watts
@ T <sub>C</sub> = 25°C		175	135		BLW St
@ T <sub>C</sub> = 100°C		100	53.8		
Derate above 25°C		1.0	1.11		W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 200	-55 to 15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
Thermal Resistance, Junction to Case	$R_{ heta}$ JC	1.0	0.93	°C/W
Lead Temperature for Soldering Purposes, 1/8" from Case for 5 Seconds	ΤL	2	75	°C

(1) Pulse Test: Pulse Width ≤ 5.0 μs, Duty Cycle ≥ 10%.

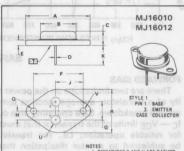
#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics are given to facilitate "worst case" design.

15 AMPERE

## NPN SILICON **POWER TRANSISTORS**

450 VOLTS 135 AND 175 WATTS



DIMENSIONS Q AND V ARE DATUMS. T. IS SEATING PLANE AND DATUM.
POSITIONAL TOLERANCE FOR
MOUNTING HOLE Q: ♦ \$.13 (0.005) @ T V @ FOR LEADS: ♦ \$.13 (0.005) @ T V @ Q @ DIMENSIONS AND TOLERANCES PER ANSI Y14.5, 1973. **CASE 1-05** 

MJH16010 MJH16012

CASE 340-01 TO-218AC

TO-204AA (Formerly TO-3)

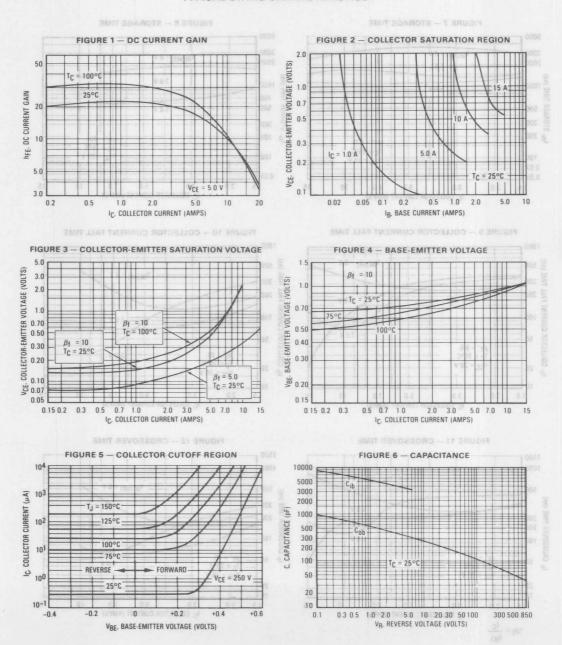
# MJ16010 MJH16010

Sinti	Characteristic	2000	Symbor	Symbol	Min	Тур	Max	Unit	
OFF CHARACTE	RISTICS						Enistics	TOARAHO T	
Collector-Emitter S	Sustaining Voltage (Table = 0)	2)	VCEO(ses)	VCEO(sus)	450	ilds11 <u>sg</u> 6NoV	G = 0)	Vdc	
	urrent c, VBE(off) = 1.5 Vdc) c, VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)	V301	ICEV	100001	1.5 <u>V</u> dc. Tg	0.25	mAdc	
Collector Cutoff Co (VCE = 850 Vdc,	urrent R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)		8301	ICER	- 1	1. 7 <sub>C</sub> = 100°C	2.5	mAdc	
Emitter Cutoff Cur (VEB = 6.0 Vdc,			- C#3;	IEBO	-	-	1.0	mAdc	
SECOND BREAK	DOWN-						MINOGW	COND BREA	
Second Breakdow	n Collector Current with I	Base Forw	ard Biased	IS/b	Mass Fork	See Figure 1	5	objeste bno	
Clamped Inductive	SOA with Base Reverse	Biased	ACEBR	RBSOA	See Figure 16				
ON CHARACTER		5.000				out riguro .		CHARACTE	
Collector-Emitter			VCE(sat)	Var.		8,53(0)	Saturation	Vdc	
(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> (I <sub>C</sub> = 10 Adc, I <sub>B</sub>	= 0.7 Adc)			VCE(sat)	=	(3°0 <u>0</u> 1 = 5	2.5 3.0 3.0	0 = 0 0 Adc.   c = 10 Adc.   c = 10 Adc.	
Base-Emitter Satur (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1			(sec)38V	VBE(sat)	Ξ	(3°0 <u>0</u> 1°5)	1.5 1.5	Vdc	
DC Current Gain (I <sub>C</sub> = 15 Adc, V <sub>C</sub>	E = 5.0 Vdc)	0.3	340	hFE	5.0	-	obV 0 8 = 30	Current Gain	
DYNAMIC CHAR	ACTERISTICS	Life Life				838	RACTERIS	NAMIC CHA	
Output Capacitano (V <sub>CB</sub> = 10 Vdc, I	e E = 0, f <sub>test</sub> = 1.0 kHz)		do3	C <sub>ob</sub>	-	(sHsi O f =	400	pF	
SWITCHING CHA	ARACTERISTICS					STICS	LARACTERI	тенив с	
Resistive Load (Ta	able 1)						[F.61817]	) bead evider	
Delay Time	20 10 1		61	t <sub>d</sub>		20	08 = eth	ns	
Rise Time	(I <sub>C</sub> = 10 Adc,	(IB2 = 2	2.6 Adc,	tr	1 520	200	3000	prniT e	
Storage Time	V <sub>CC</sub> = 250 Vdc,	R <sub>B</sub> = 1.		ts	1-98	1200	1 a red	rage Time	
Fall Time	I <sub>B1</sub> = 1.3 Adc,			tf		200	K = VA	Time	
Storage Time	PW = 30 μs,			t <sub>S</sub>	La rate	650	O vart	omiT egs	
Fall Time	Duty Cycle ≤2.0%)	(VBE(of	ff) = 5.0 Vdc)	tf	_	80	-	Time	
Inductive Load (Ta	able 2)						(S olde)	DEGJ SVIDSL	
Storage Time	680 1800		128	t <sub>sv</sub>		800	1800	ns	
Fall Time	(I <sub>C</sub> = 10 Adc,	(T <sub>C</sub> = 100°C)		tfi	1-2	50	200	emiT	
Crossover Time	I <sub>B1</sub> = 1.3 Adc,			t <sub>C</sub>	_	90	250	sover Yenne	
Storage Time	VBE(off) = 5.0 Vdc,		V82	tsv		1050	250	amil' ags	
Fall Time	V <sub>CE(pk)</sub> = 400 Vdc)	(T <sub>C</sub> = 1	50°C)	tfi	1-21	70	2013:25	emil	
Crossover Time	CE(pk) 100 tac)	1.6	1 0	t <sub>C</sub>		120		emil revose	

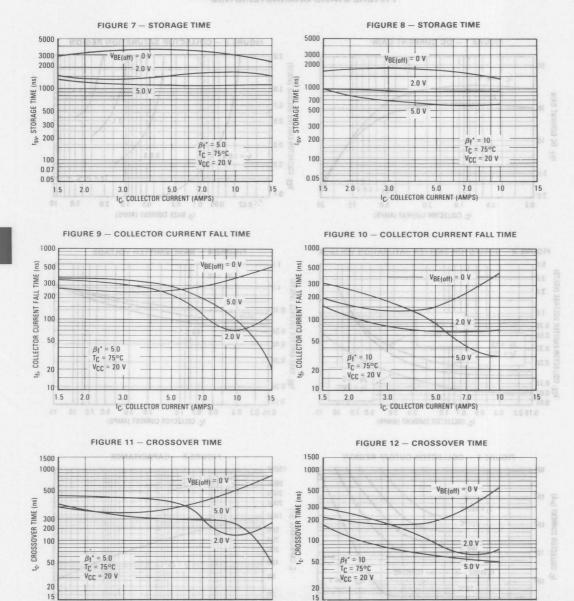
# MJ16012 MJH16012

	Characteristic	milds.	Symbol	Symbol	Min	Тур	Max	Unit
OFF CHARACTER	RISTICS						0.0000000	TOARANO
Collector-Emitter 9	Sustaining Voltage (Table	21		Vocat	450			Vdc
(I <sub>C</sub> = 100 mA, I <sub>B</sub>		45012		VCEO(sus)	450 18 9	idsT) scelloV	Sustaining lo = 0)	Am 001 = n
Collector Cutoff Cu	irrent		vaol	ICEV			smeani.	mAdc
	, VBE(off) = 1.5 Vdc)				-	(1.5 Vec)	0.25	CEV = 850 )
(V <sub>CEV</sub> = 850 Vdc	, VBE(off) = 1.5 Vdc, TC	100°C)			: 160°C)	of vide Le	1.5	/ 088 = wan
Collector Cutoff Cu				CER	-	-	2.5	mAdc
(V <sub>CE</sub> = 850 Vdc,	$R_{BE} = 50 \Omega, T_{C} = 100^{\circ}C$					To = Tebec	Rec = 501	Ce = 850 Vd
Emitter Cutoff Curi				<sup>I</sup> EBO	-	-	1.0	mAdc
(VEB = 6.0 Vdc, I	C = 0)		-				10 = ol :	6V 0.8 = 69
SECOND BREAK	DOWN						- wwo as	LINE GMO
Second Breakdown Collector Current with Base Forward Bia				IS/b	See Figure 15			ond Breekdo
Clamped Inductive	SOA with Base Reverse	Biased	AGBBA	RBSOA	bessid s	See Figure 1	e SOA with	included begin
ON CHARACTER	ISTICS (1)						1. POLITAGO	CHARACTE
Collector-Emitter S	Saturation Voltage	TENTO		V <sub>CE(sat)</sub>				Vdc
(IC = 5.0 Adc, IB				OL(301)		Politage	2.5	ector amaze
(IC = 10 Adc, IB =					-	-	3.0	= 10 Ade 1
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> =	1.0 Adc, T <sub>C</sub> = 100°C)				-	10°0001 = 51	3.0	.abA 07 =
Base-Emitter Satu				VBE(sat)		904	nev neiteru	Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> =					-	-	1.5	= 10 Adc.
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> =	= 1.0 Adc, T <sub>C</sub> = 100°C)					(c = 100°C)	ob 1,5	= 10 Adc.
DC Current Gain				hFE	7.0	-	-	nis Dutrent Cain
(I <sub>C</sub> = 15 Adc, V <sub>CE</sub>	= 5.0 Vdc)						66 - 6.0 Vdd	15 Adc. V
DYNAMIC CHAR	ACTERISTICS					808	RACTERIS	MANUE CHE
Output Capacitano				Cob	-	-	400	PF NO
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub>	= 0, f <sub>test</sub> = 1.0 kHz)					tsibt 0.1 =	ign of tone	aby of a ac
SWITCHING CHA	RACTERISTICS					snics		
Resistive Load (Ta	ble 1)						Table 1)	baoJ avisa
Delay Time	(I <sub>C</sub> = 10 Adc, 05		l bi	td	- 1	20	- 1	ns T
Rise Time	V <sub>CC</sub> = 250 Vdc,	(IB2 = 2	2.0 Adc,	t <sub>roba 8</sub>	$(\overline{\omega}_{2} = 2$	200	31 - 31	Time
Storage Time	I <sub>B1</sub> = 1.0 Adc,	R <sub>B</sub> = 1.	6 Ω)	t <sub>s</sub> 10 8	1 - 30	900	- 33 <u>-</u> 2	emil ses
Fall Time	PW = 30 μs,		1	tf	-	150	1 2 10	Time
Storage Time	Duty Cycle ≤2.0%)	(Vpc)	ff) = 5.0 Vdc)	t <sub>S</sub>	-	500	# = AAB	age Time
Fall Time	08	(*BE(0)	1, 0.0 (00)	tf	lois(IV)	40	NO YNOU . F	Firms
Inductive Load (Ta	able 2)						(S eldeT	baoJ avito
Storage Time	0081 008		l vot	tsv		650	1500	ns
Fall Time	(I <sub>C</sub> = 10 Adc,	(T <sub>C</sub> = 1	00°C)	tfi men	10 = 10	30	150	Smit Sge
Crossover Time	I <sub>B1</sub> = 1.0 Adc,			t <sub>C</sub>	-	50	200	sever Time
Storage Time	VBE(off) = 5.0 Vdc,		1 5007	t <sub>sv</sub>	_	850	Nautor -	omiT age
Fall Time	VCE(pk) = 400 Vdc)	(T <sub>C</sub> = 1	50°C)	tfi	0 = 50	30	4.0250	gasi'i
Crossover Time				t <sub>C</sub>	-	70	-	and Traves

#### TYPICAL STATIC CHARACTERISTICS



## TYPICAL DYNAMIC CHARACTERISTICS



5.0

IC. COLLECTOR CURRENT (AMPS)

7.0

10

2.0

1.5

3.0

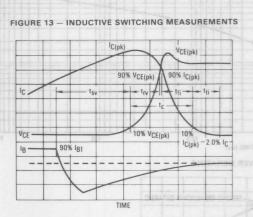
5.0

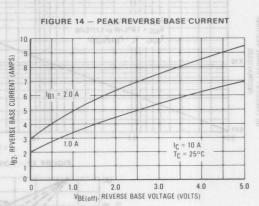
IC. COLLECTOR CURRENT (AMPS)

10

15

15





#### **GUARANTEED SAFE OPERATING AREA LIMITS**

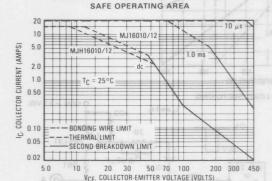
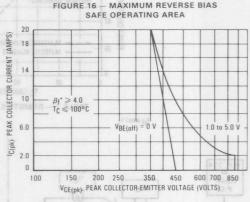


FIGURE 15 - MAXIMUM FORWARD BIAS



#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

\* $\beta_f = \frac{1C}{I_{B1}}$ 

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

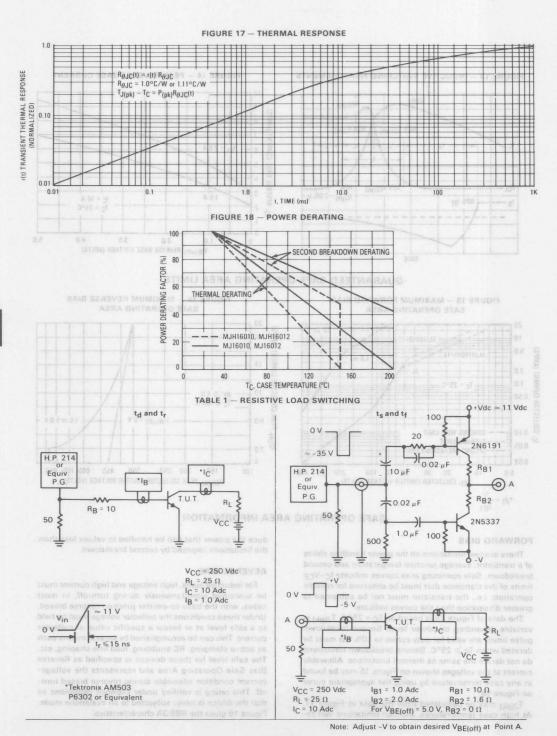
The data of Figure 15 is based on  $T_C=25^\circ C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^\circ C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

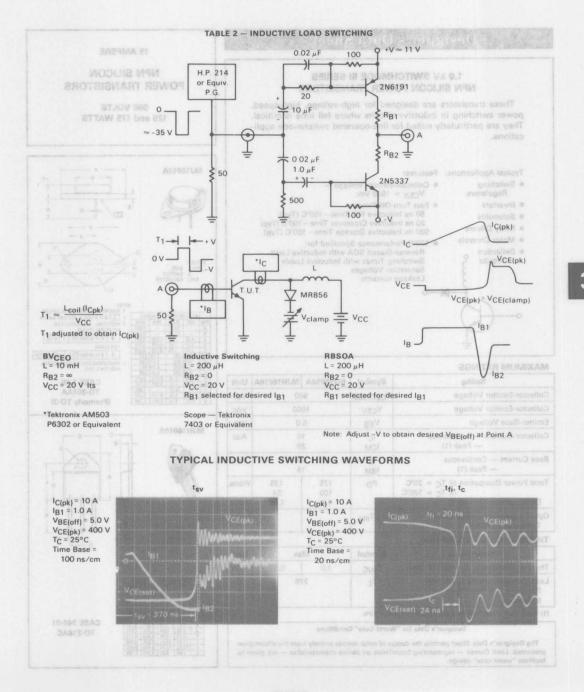
T<sub>J(pk)</sub> may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will re-

duce the power that can be handled to values less than the limitations imposed by second breakdown.

## REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.







# Designer's Data Sheet

### 1.0 kV SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode appli-

Typical Applications: Features:

- Switching Regulators
- Inverters
- Solenoids
- Relay Drivers
- Motor Controls



• Collector-Emitter Voltage — V<sub>CEX</sub> = 1000 Vdc

 Fast Turn-Off Times 50 ns Inductive Fall Time – 100°C (Typ) 90 ns Inductive Crossover Time – 100°C (Typ) 900 ns Inductive Storage Time - 100°C (Typ)

• 100°C Performance Specified for: Reverse-Biased SOA with Inductive Load Switching Times with Inductive Loads Saturation Voltages Leakage currents

#### MAXIMUM RATINGS

SPALLY INIOINI VALIANO				
Rating	Symbol	MJ16010A	MJH16010A	Unit
Collector-Emitter Voltage	VCEO(sus)	et 19R 5	oo ial bana	Vdc
Collector-Emitter Voltage	VCEV	10	000	Vdc
Emitter-Base Voltage	VEB	6	Vdc	
Collector Current — Continuous — Peak (1)	I <sub>C</sub> M	15 20		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub> M	W DWHC10 WZ 3VII 15		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $T_C = 25^{\circ}C$	PD	175 100 1.0	135 54 1.09	Watts W/°C
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	18) = 1.0 A VBS(dB) * 5		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	M	Unit	
Thermal Resistance, Junction to Case	R <sub>O</sub> JC	1.0	0.92	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275		°C

(1) Pulse Test: Pulse Width = 5.0 ms, Duty Cycle ≤ 10%.

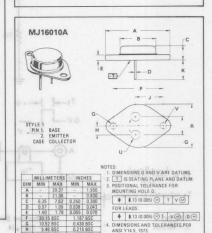
## Designer's Data for "Worst Case" Conditions

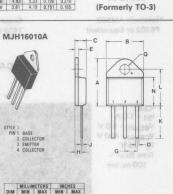
The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit Curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

#### 15 AMPERE

## **NPN SILICON POWER TRANSISTORS**

**500 VOLTS** 125 and 175 WATTS





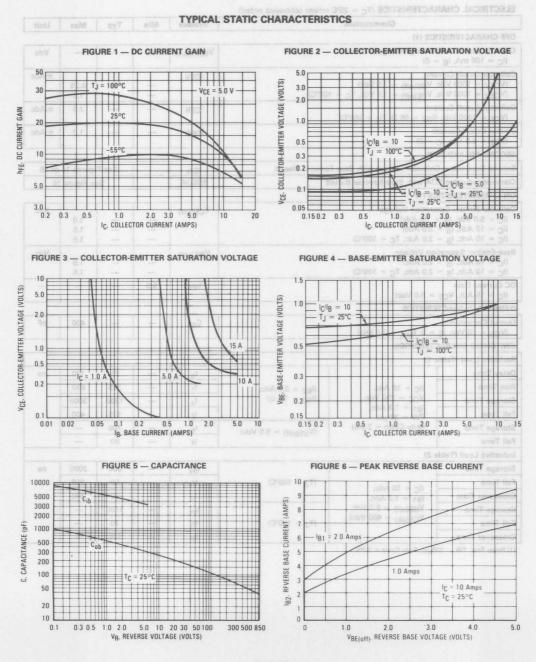


CASE 340-01 TO-218AC

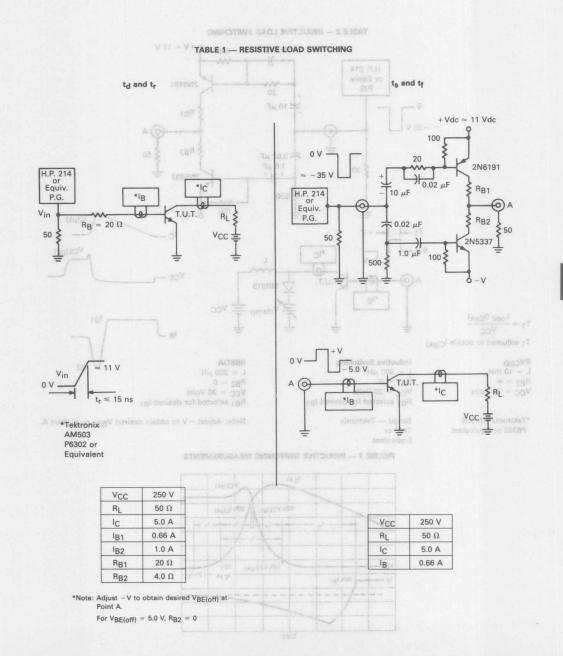
**CASE 1-05** TO-204AA

	Symbol	Min	Тур	Max	Unit			
OFF CHARACTERIST	TICS (1)							
Collector-Emitter Su: (I <sub>C</sub> = 100 mA, I <sub>B</sub>	VCEO(sus)	500		-PG	Vdc			
	rent c, VBE(off) = 1.5 Vdc) c, VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)	ICEV		) <del>( </del>	0.25 1.5	mAde	
Collector Cutoff Curr (V <sub>CE</sub> = 1000 Vdc,	ICER		28°C	2.5	mAd			
Emitter Cutoff Curre (VEB = 6.0 Vdc, Ic		= a.o. a	IEBO			1.0	mAd	
SECOND BREAKDON	WN - 2 BUT - UT	60 2 1		(G) p in the c	3,01		- 01	
Second Breakdown	Collector Current with Base	Forward Biased	IS/b		See Figures 14			
Clamped Inductive S	SOA with Base Reverse Biase	ed	RBSOA		Se	See Figure 16		
ON CHARACTERIST	ICS (1)	13 's						
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc, T <sub>C</sub> = 100°C)				E <u>6.5</u> MERRIUD SO	0.1 103.100 .01	1.0 1.5 1.5	Vdc	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 2.0 Adc, T <sub>C</sub> = 100°C)				ASTTIM	B-80T03.	1.5 1.5	Vdd	
DC Current Gain (I <sub>C</sub> = 15 Adc, V <sub>CE</sub>	hFE	5.0		1-1	0.0			
DYNAMIC CHARACT	TERISTICS	607 6 計計	1 制工制计				10	
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub>	= 0, f <sub>test</sub> = 1.0 kHz)		C <sub>ob</sub>	H		400	pF	
SWITCHING CHARA	CTERISTICS		1 1				0	
Resistive Load (Tabl	le 1)						=   81	
Delay Time		1	t <sub>d</sub>	8 -	25	100	ns	
Rise Time	(I <sub>C</sub> = 10 Adc,	(I <sub>B2</sub> = 2.6 Adc,	t <sub>r</sub>		325	600	1.2	
Storage Time	V <sub>CC</sub> = 250 Vdc,	$R_{B2} = 1.6 \Omega$	ts	-	1300	3000		
Fall Time	$I_{B1} = 1.3 \text{ Adc},$ $PW = 30 \mu s,$	Lies William	tf		175	400	وراسا	
Storage Time	Duty Cycle ≤ 2.0%)	(V <sub>BE(off)</sub> = 5.0 Vdc)	ts	E CLIMBERT	700	50.5	10:0	
Fall Time	training north and St.	( BE(OII)	tf	_	80	_		
Inductive Load (Tab	le 2)							
Storage Time	E 8 — PEAK NEVERSE BASE	RLIDA .	t <sub>sv</sub>	MAG	900	2000	ns	
Fall Time	//o = 10 Ado	(T <sub>J</sub> = 100°C)	tfi	S SUTE F	50	250	808	
Crossover Time	(I <sub>C</sub> = 10 Adc, I <sub>B1</sub> = 1.3 Adc,		t <sub>c</sub>		90	300	000	
Storage Time	VBE(off) = 5.0 Vdc,		t <sub>sv</sub>	1-1	1100	11-11	980	
Fall Time VCE(pk) = 400 Vdc)		(T <sub>J</sub> = 150°C)	tfi		70	-	500	
Crossover Time	II have no		t <sub>c</sub>		120	1000	13 000	









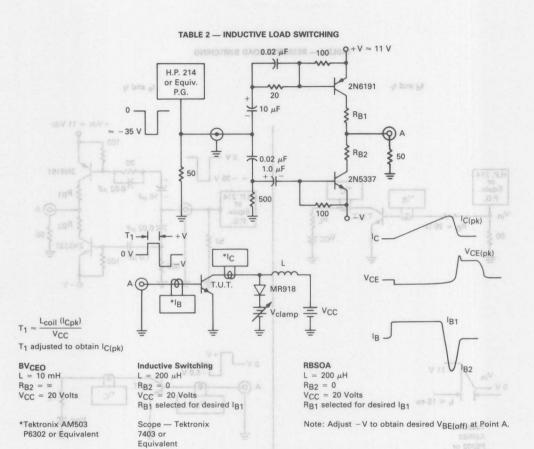
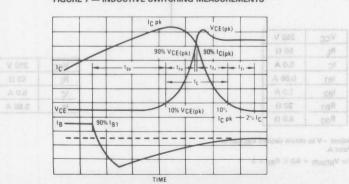
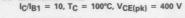


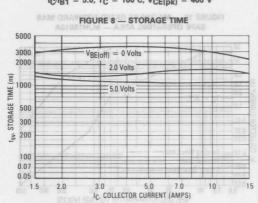
FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS

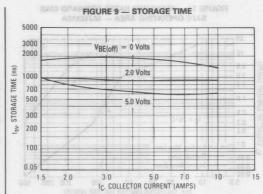


#### TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS

I<sub>C</sub>/I<sub>B1</sub> = 5.0, T<sub>C</sub> = 100°C, V<sub>CE(pk)</sub> = 400 V

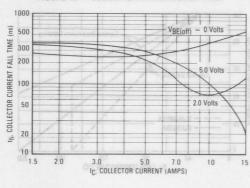


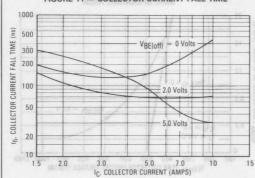




#### FIGURE 10 - COLLECTOR CURRENT FALL TIME

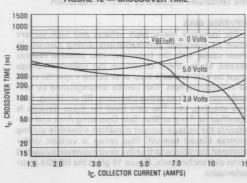
#### FIGURE 11 — COLLECTOR CURRENT FALL TIME

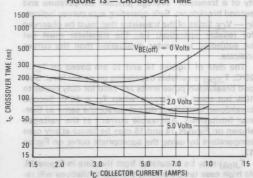




#### FIGURE 12 — CROSSOVER TIME

#### FIGURE 13 — CROSSOVER TIME





## GUARANTEED OPERATING AREA INFORMATION

FIGURE 14 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA — MJ16010A

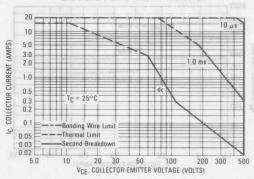
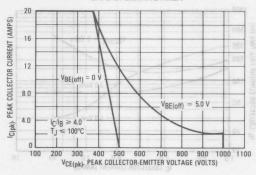


FIGURE 16 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 14 and 15 are based on  $T_C=25^{\circ}C;\,T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C.$  Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 14 and 15 may be found at any case temperature by using the appropriate curve on Figure 17.

T<sub>J(pk)</sub> may be calculated from the data in Figure 18. At high case temperatures, thermal limitations will re-

FIGURE 15 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA — MJH16010A

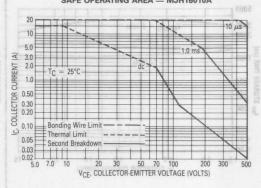
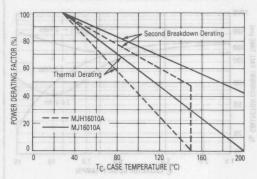


FIGURE 17 — POWER DERATING

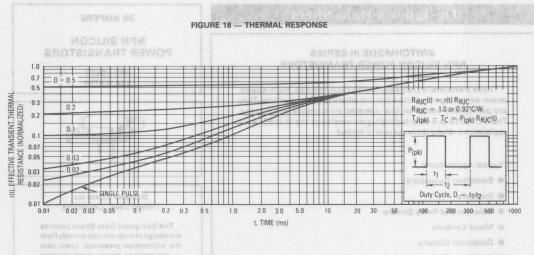


duce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable putting reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.





@ Fast Turn-Off Times Operating Temperature Range -65 to +200 VC

@ 100°C Performance Specified for.

CONTINUE BEUGHIAM			
	Symbol		
offector-Emitter Veltage			
mitter Base Voltage	VEB		
	ol lond		
		250 143 1.43	Wans

	usM	lodmy8	Characteristic
			Thermal Resistance, Junetion to Case



### Designer's Data Sheet

## SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications. The MJ16016 is a selected high-gain version of the MJ16014 for applications where drive current is limited.

Typical Applications:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits
- Fast Turn-Off Times
   40 ns Inductive Fall Time 75°C (Typ)
   40 ns Inductive Crossover Time 75°C (Typ)
   800 ns Inductive Storage Time 75°C (Typ)
- Operating Temperature Range -65 to +200°C
- 100°C Performance Specified for:
   Reverse-Biased SOA with Inductive Loads
   Switching Times with Inductive Loads
   Saturation Voltages
   Leakage Currents

#### MAXIMUM RATINGS

Rating	Symbol	Max	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	450	Vdc
Collector-Emitter Voltage	VCEV	850	Vdc
Emitter Base Voltage	VEB	6.0	Vdc
Collector Current — Continuous — Peak (1)	IC ICM	20 30	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	10 20	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	250 143 1.43	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	0.7	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 20 AMPERE

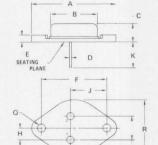
#### NPN SILICON POWER TRANSISTORS

450 VOLTS 250 WATTS



#### Designer's Data for 'Worst Case'' Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	38.35	39.37	1.510	1.550
В	19.30	21.08	0.760	0.830
C	6.35	7.62	0.250	0.300
D	1.45	1.60	0.057	0.063
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
Н	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
0	3.84	4.09	0.151	0.161
R	24.89	26.67	0.980	1.050

CASE 197-01 MODIFIED TO-3

3

### MJ16014

	Characteristic			Symbol	Min	Тур	Max	Unit
OFF CHARACTER	RISTICS	gille	fodniyê.			oirshelosts	NO.	
	Sustaining Voltage (Table	2)		Voco	450		sonems	Vdc
(Ic = 100 mA, IB		450	VCED(sus)	VCEO(sus)	(8)	Voltage (Table	Sustaining	estimă-rotae
Collector Cutoff Cu				ICEV			(0 - 6	mAdc
	, V <sub>BE(off)</sub> = 1.5 Vdc)			ICEV			0.25	CEV = 850 /
	, VBE(off) = 1.5 Vdc, TC =	100°C)			100001	1.5 VHC TO	1.5	A 068 = A30
Collector Cutoff Cu		10000	REOI	ICER	19.00		2.5	mAdc
	R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)			CLI		2°001 = 3T.	. 8gg = 50 r	CE = 850 Vd
Emitter Cutoff Curi	rent		0.83	IEBO	_	-	1.0	mAdc
(VEB = 6.0 Vdc, I	C = 0)						(0 = 0)	18V 0.8 = 83
SECOND BREAK	DOWN						MWOGN	
Second Breakdown	Collector Current with E	Base Forw	ard Biased	IS/b		See Figure 1	5	COACUTE DIS
Clamped Inductive	SOA with Base Reverse	Biased	AUGSIII	RBSOA	UNEUR	See Figure 1	6	risson saq
ON CHARACTER	ISTICS (1)						(I) correin	STURMENO
Collector-Emitter S	Saturation Voltage		(188)50	V <sub>CE(sat)</sub>	TE TOTAL		(ab4. 0. f = )	Vdc
(I <sub>C</sub> = 10 Adc, I <sub>B</sub> =				CE(Sat)			2.5	= 15 Adq. II
(IC = 15 Adc, IB =						C= 1008C1	3.0	= 15 Ado.
	2.0 Adc, T <sub>C</sub> = 100°C)				_	_ 96	3.0	-Emitter Sa
Base-Emitter Satur	ration Voltage			VBE(sat)	16781	(3°001 = 5	a I S Ade T	Vdc
(IC = 15 Adc, IB =	2.0 Adc)			52(501)		13 001 13	1.5	1 1000000
	2.0 Adc, T <sub>C</sub> = 100°C)				-	_	1.5	errent Grave = 20 Add >
DC Current Gain				hFE	5.0	- 201	RACTERIST	AMIC CHA
(IC = 20 Adc, VCI	= 5.0 Vdc							ationach ta
DYNAMIC CHAR	ACTERISTICS							
Output Capacitanc	е			Cob	_	-80178	500 A	TO D pFHOT
(VCB = 10 Vdc, IE	= 0, f <sub>test</sub> = 1.0 kHz)						IT alds1	beel avus
SWITCHING CHA	RACTERISTICS							Time
Resistive Load (Ta	ble 1)	444	1 9	.00A 0	g = kBy	iO Vde	Vec= 28	smit
Delay Time	008		3	td	- 84	20	50	ns
Rise Time	(I <sub>C</sub> = 15 Adc,	(lB2 = 4	.O Adc,	tr		200	500	emil eg
Storage Time	V <sub>CC</sub> = 250 Vdc,	R <sub>B</sub> = 1.	6 Ω)	ts	101357	1200	2700	ami
Fall Time	I <sub>B1</sub> = 2.0 Adc, PW = 30 μs,			tf		200	350	
Storage Time	Pvv = 30 μs, Duty Cycle ≤2.0%)	(Vac.	(f) = 5.0 Vdc)	ts		650	12 6/631	bood svito
Fall Time	Duty Cycle (2.0%)	(ARF(O	1) - 3.0 (00)	tf		80	-	iga Time
Inductive Load (Ta	ble 2)		111	15.0	317	700 P	21 - 20	naven Tumn
Storage Time	- 00e			t <sub>sv</sub>	_	800	2700	ns
Fall Time	(I <sub>C</sub> = 15 Adc,	(TC = 1	00°C)	tfi	102315	50	200	b/mil
Crossover Time	I <sub>B1</sub> = 2.0 Adc,			t <sub>c</sub>	_	90	250	ampT revos
Storage Time	VBE(off) = 5.0 Vdc,			t <sub>sv</sub>	_	1050	-	WS IZeTest
Fall Time	V <sub>CE(pk)</sub> = 400 Vdc)	$(T_C = 1)$	50°C)	tfi	-	70	1100 28 000	74 123 0E
Crossover Time				tc	_	120	-	1

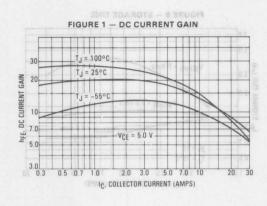
<sup>(1)</sup> Pulse Test: PW - 300  $\mu$ s, Duty Cycle  $\leqslant$ 2%.
\*  $\beta f = \frac{I_C}{I_{B1}}$ 

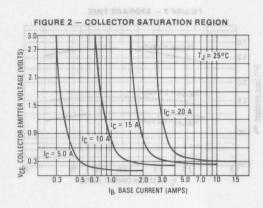
### MJ16016

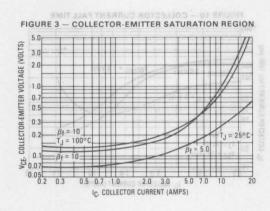
MJ16014

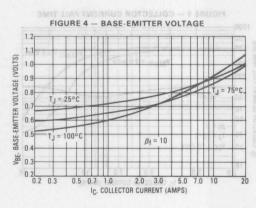
	Characteristic		-	Symbol	Min	Тур	Max	Unit
OFF CHARACTE	DISTICS						2.107.8196.5	LUANANU T
Velo		DEN	Vecce(sus)	Tv T	450	Voltage (Table		Hector-Emilts
(I <sub>C</sub> = 100 mA, I <sub>B</sub>	Sustaining Voltage (Table = 0)	2)		VCEO(sus)	450		T0 = 8	A. Vdc1 = 5
	urrent c, VBE(off) = 1.5 Vdc) c, VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)		ICEV	100201	1.5 <u>Va</u> c. 7 <sub>C</sub> =	0.25 1.5	V CEV = 850 V
Collector Cutoff Cu (VCE = 850 Vdc,	urrent R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	-	яар!	ICER	-		2.5 Tul	mAdc
(VEB = 6.0 Vdc,			083)	<sup>I</sup> EBO		-	1.0	mAdc and
SECOND BREAK	DOWN						MARIO CON	COND BREA
Second Breakdow	n Collector Current with B	ase Forwa	ard Biased	IS/b		See Figure 15		
Clamped Inductive	SOA with Base Reverse	Biased	6.8	RBSOA	LATON DAS	See Figure 16	vetsein Lav	CATASTE DAGS
ON CHARACTER	HISTICS (1)		AGSBR		bassi8	Bago Reverse	10W AGS 0	thused bagon
				I w l I			n sorrain	TOARANO Y
Collector-Emitter S (IC = 10 Adc, IR	Saturation Voltage			VCE(sat)		ansito\	2.5	Vdc
(IC = 15 Adc, IB								le = 10 Adc. la
	= 1.5 Adc, T <sub>C</sub> = 100°C)			15-33-63	_		3.0	le = 15 Ade. le
Base-Emitter Satu	ration Voltage	-	4	V <sub>BE(sat)</sub>	P = 7.0	(3°001 = 5)	= 2.0 Adc	Vdc
(IC = 15 Adc, IB	= 1.5 Adc)			o E (out)		-	1.5	to Emirar Spi
(IC = 15 Adc, IB	= 1.5 Adc, T <sub>C</sub> = 100°C)		(180)367		- 1		1.5	Nuo minimaren
DC Current Gain (I <sub>C</sub> = 20 Adc, V <sub>C</sub>	E = 5.0 Vdc			hFE	7.0	(0°001 = p	= 2.0 Ado.	ic = 15 Ade. lg
DYNAMIC CHAP	RACTERISTICS	0.6	384					Durent Gain
Output Capacitano (V <sub>CB</sub> = 10 Vdc, I	ce E = 0, f <sub>test</sub> = 1.0 kHz)			C <sub>ob</sub>		103	500	PF PAMIC CHA
SWITCHING CHA	ARACTERISTICS		do5	17-2			931	tput Capeonar
Resistive Load (Ta	able 1)					(sHx 0.1 =	(g = 0, ftest	VCB = 10 Vdc.
Delay Time				t <sub>d</sub>	_	20017	50	HO Das HOTH
Rise Time	(I <sub>C</sub> = 15 Adc,	(I <sub>B2</sub> = 3	I.O Adc.	tr	_	200	500	sistive Load ()
Storage Time	V <sub>CC</sub> = 250 Vdc,	R <sub>B</sub> = 1.		ts	_	900	2200	
Fall Time	I <sub>B1</sub> = 1.5 Adc,			tf	-	100	250	amiT yu
Storage Time	PW = 30 μs, Duty Cycle ≤2.0%)	(Vpr.	f) = 5.0 Vdc)	ts	# = (T)	500	VED = 2	emil s
Fall Time	Buty Cycle 42.0707	(*BE(O)	1) - 3.0 vac)	t <sub>f</sub> (31)	2.1 *27	40	(81 = 2.0	rage Time
Inductive Load (T	able 2)							emil sper
Storage Time	08		1 7	tsv	Hoja <u>a</u> Vi	750	2500	ns
Fall Time	(I <sub>C</sub> = 15 Adc,	(TC = 10	00°C)	tfi		30	150	beoJ syltau
Crossover Time	IB1 = 1.5 Adc,			tc		50	200	
Storage Time	VBE(off) = 5.0 Vdc,		VK.	t <sub>sv</sub>	_	900	_	rage Time
Fall Time	VCE(pk) = 400 Vdc)	(TC = 1	50°C)	tfi	M1 - 211	30	= ( - 20)	Time ssover Time
Crossover Time	VOA (78		31	tc	-	70	7 - 10	Still Save 28
1) Pulse Test: PW -	300 μs, Duty Cycle ≤2%.							
$^*\beta_f = \frac{I_C}{I_{B1}}$								saover Time

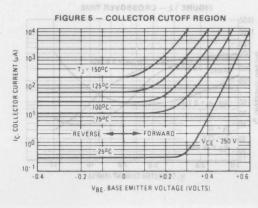
#### TYPICAL STATIC CHARACTERISTICS

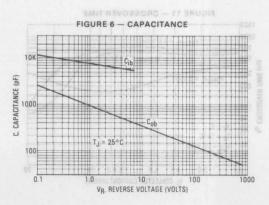




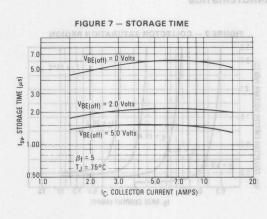


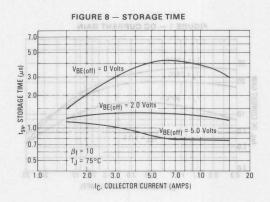


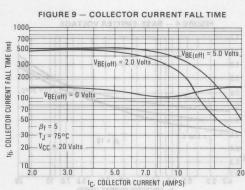


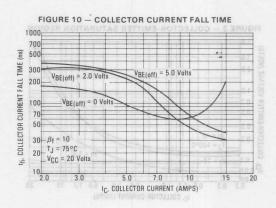


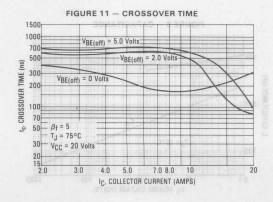
#### TYPICAL DYNAMIC CHARACTERISTICS

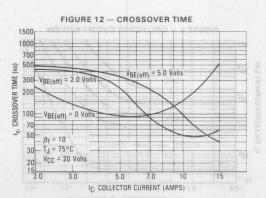












= 3.0 Amps

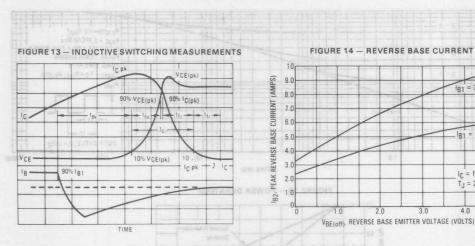
= 1.5 Amps

Ic = 15 Amps

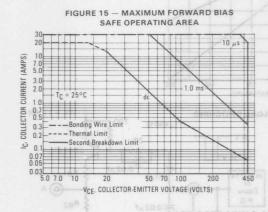
5.0

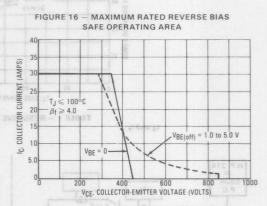
T<sub>J</sub> = 25°C





#### **GUARANTEED SAFE OPERATING AREA LIMITS**





#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCF limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

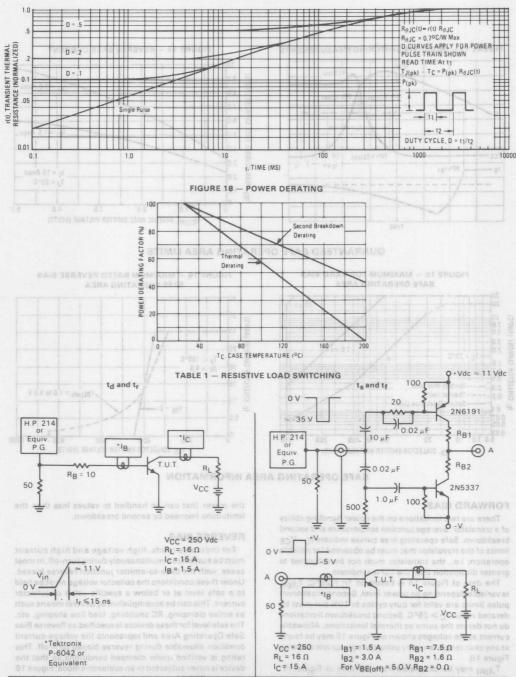
The data of Figure 15 is based on Tc = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ} \text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 18.

T<sub>J(pk)</sub> may be calculated from the data in Figure 17. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

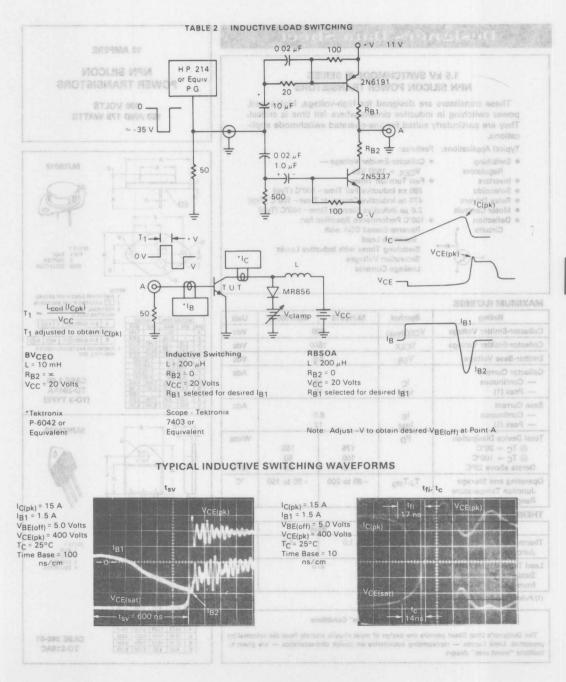
#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 16 gives the RBSOA characteristics.

#### FIGURE 17 - THERMAL RESPONSE



\*Note: Adjust -V to obtain desired VBE(off) at Point A.





### **Designers Data Sheet**

#### 1.5 kV SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode appli-

Typical Applications: Features:

- Switching Regulators
- Inverters
- Solenoids Relay Drivers
- Motor Controls
- Deflection Circuits
- VCEX = 1500 Vdc Fast Turn-Off Times 280 ns Inductive Fall Time - 100°C (Typ) 470 ns Inductive Crossover Time - 100°C (Typ)

Collector-Emitter Voltage —

• 100°C Performance Specified for: Reverse-Biased SOA with Inductive Load

2.6 µs Inductive Storage Time - 100°C (Typ)

Switching Times with Inductive Loads Saturation Voltages Leakage Currents

#### **MAXIMUM RATINGS**

Rating	Symbol	MJ16018	MJH16018	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	80	00	Vdc
Collector-Emitter Voltage	VCEX	15	00	Vdc
Emitter-Base Voltage	VEB	6.	.0	Vdc
Collector Current  — Continuous  — Peak (1)	IC ICM		0 5	Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>		.0	Adc
Total Device Dissipation  @ T <sub>C</sub> = 25°C  @ T <sub>C</sub> = 100°C  Derate above 25°C	PD	175 100 1.0	150 50 1.0	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to 200	-55 to 150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Alloh A	Max	Unit
Thermal Resistance, Junction to Case	ROC	1.0	1.0	°C/W
Lead Temperature for Soldering Purposes, 1/8" from Case for 5 Seconds.	TL		275	°C

(1) Pulse Test: Pulse Width  $\leq$  5.0  $\mu$ s, Duty Cycle  $\geq$  10%.

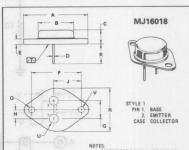
#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit Curves - representing boundaries on device characteristics - are given to facilitate "worst case" design.

#### 10 AMPERE

#### **NPN SILICON POWER TRANSISTORS**

800 VOLTS 150 AND 175 WATTS

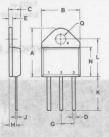


- ES:
  DIMENSIONS Q AND V ARE DATUMS.
  T: IS SEATING PLANE AND DATUM.
  POSITIONAL TOLERANCE FOR
  MOUNTING HOLE Q:

MILLIA	METERS	INC	HES	1	-	\$.13 (0.005) (a)	-	VO	
MIN	MAX	MIN	MAX			#.13 (U.005) (m)	1	16	2
-	39.37	inte.	1.550	1-9	FORL	EADS:			
-	21.08		0.830	100	4	Ø.13 (0.005) (△) T	L	(M)	0(4)
6.35	7,62	0.250	0.300	1	-		-	_	-0
0.97	1.09	0.038	0.043	4.	DIME	ISIONS AND TOLE	RAN	ICES	PER

**CASE 1-05** TO-204AA (TO-3 TYPE)

MJH16018



	MILLIN	METERS	INC	HES
MIG	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
0	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	2.41	3.20	0.095	0.126
1	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
0	4.04	4.22	0.159	0.166

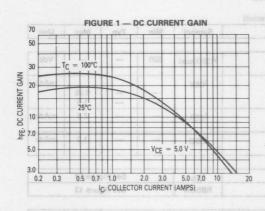
1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR

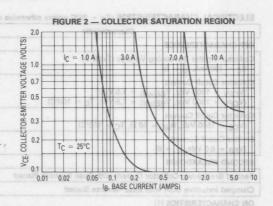
**CASE 340-01** TO-218AC

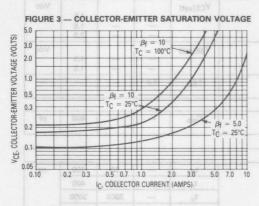
## MJ16018 MJH16018

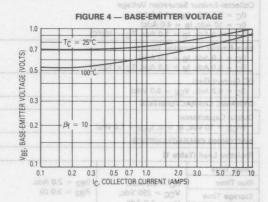
	Character	istic	Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS						
Collector-Emitter (I <sub>C</sub> = 100 mA,	Sustaining Voltage (Tab I <sub>B</sub> = 0)	le 2)	VCEO(sus	800	-	5/09/ = 3	Vdc
(V <sub>CEV</sub> = 1500	Collector Cutoff Current (VCEV = 1500 Vdc, VBE(off) = 1.5 Vdc) (VCEV = 1500 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 100°C)		ICEV	1		0.25 1.5	mAdd
Collector Cutoff Current (VCE = 1500 Vdc, R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)		ICER			2.5	mAdo	
Emitter Cutoff Current (VEB = 6.0 Vdc, IC = 0)			IEBO	2 = 10V I		1.0	mAdo
SECOND BREAKI	DOWN	The state of		1 1 - 1			
Second Breakdov	vn Collector Current with	Base Forward Biased	IS/b	08 08	See Fig	gure 12	2 0.3
Clamped Inductive SOA with Base Reverse Biased			RBSOA	A) THERENI (A	See Fi	gure 13	
ON CHARACTER	STICS (1)		BERLARIE	BETT			
$(I_C = 5.0 \text{ Adc}, I_C = 10 \text{ Adc}, I_C = 10$	Saturation Voltage I <sub>B</sub> = 1.0 Adc) B = 4.0 Adc) I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100°		VCE(sat)	1 3 - 1	V3-77010	1.5 1.5 2.0	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100°C)		VBE(sat)	Trees = 5		1.5 1.5	Vdc	
DC Current Gain (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		hFE	7.0			-	
DYNAMIC CHAR	ACTERISTICS	0.0 5	HA	MAN	2725 - 27 T		
Output Capacitance (V <sub>CR</sub> = 10 Vdc, I <sub>F</sub> = 0, f <sub>test</sub> = 1.0 kHz)		Cob			400	pF	
SWITCHING CHA	RACTERISTICS						
Resistive Load (T	able 1)	1 地					
Delay Time	00 07 50 30		td	1 1	50	100	ns
Rise Time	(I <sub>C</sub> = 5.0 Adc,	(l <sub>B2</sub> = 2.0 Adc,	trime	R CHIERT OF	300	400	31
Storage Time	V <sub>CC</sub> = 250 Vdc,	$R_{B2} = 3.0 \Omega$	ts	_	2000	3000	
Fall Time	$I_{B1} = 1.0 \text{ Adc},$ $PW = 30 \mu s,$		tf	_	900	1200	
Storage Time	Duty Cycle ≤ 2.0%)	(VBE(off) = 2.0 Vdc)	ts	OFFICE POR	1600	2400	
Fall Time	EL CLEMENT BY	DE(OII)	t <sub>f</sub>	1-1	500	650	
Inductive Load (1	able 2)		HAYA	Sel			
Storage Time			t <sub>sv</sub>	13-1	2000	3000	ns
Fall Time	(I <sub>C</sub> = 5.0 Adc,	(T <sub>J</sub> = 25°C)	tfi	11-1	200	400	
Crossover Time	I <sub>B1</sub> = 1.0 Adc,		tc	10-4	350	500	
Storage Time	VBE(off) = 2.0 Vdc,	MATTER OR S	t <sub>sv</sub>	17-4	2600	3600	
Fall Time	VCE(pk) = 400 Vdc)	$(T_J = 100^{\circ}C)$	tfi		280	460	
Crossover Time		#1 Flat   100   g	t <sub>c</sub>	11	470	620	

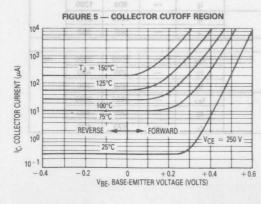
#### TYPICAL STATIC CHARACTERISTICS

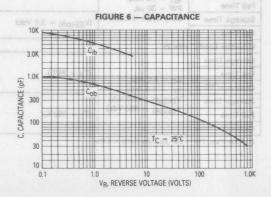




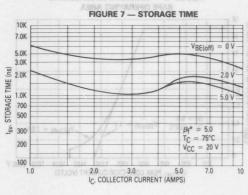


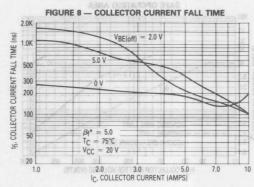


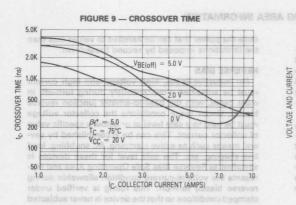


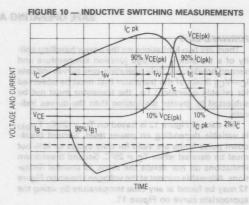


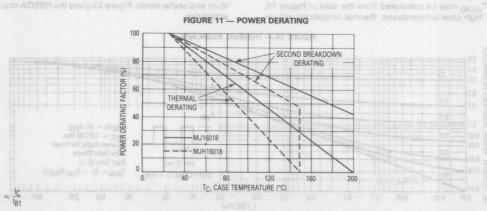
## TYPICAL INDUCTIVE SWITCHING CHARACTERISTICS (AM — ST PRUSH) (AM — ST PRUSH)



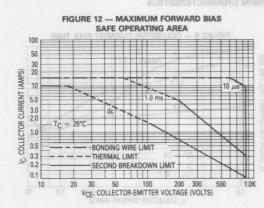


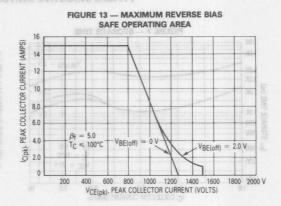






#### **GUARANTEED SAFE OPERATING AREA LIMITS**





#### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC—VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

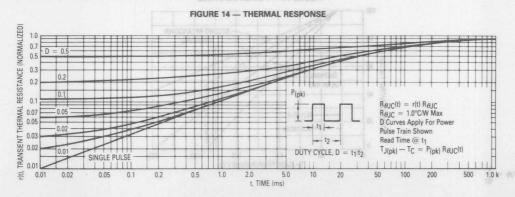
The data of Figure 12 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 11.

T<sub>J(pk)</sub> may be calculated from the data in Figure 14. At high case temperatures, thermal limitations will re-

duce the power that can be handled to values less than the limitations imposed by second breakdown.

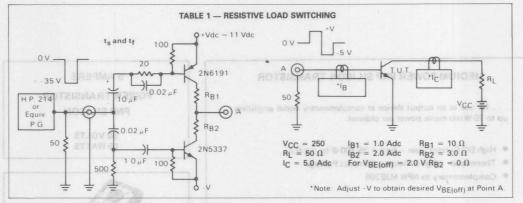
#### **REVERSE BIAS**

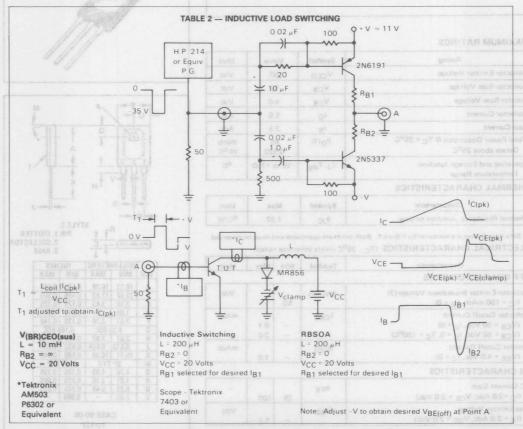
For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the RBSOA characteristics.













#### MEDIUM-POWER PNP SILICON TRANSISTOR

. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain hFE = 25-100 @ IC = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to NPN MJE205

#### 5 AMPERE

POWER TRANSISTOR PNP SILICON

> 50 VOLTS 65 WATTS



#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	50	Vdc
Collector-Base Voltage	VCB	50	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current	1 <sub>C</sub>	5.0	Adc
Base Current	1 <sub>B</sub>	2.5	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	P <sub>D</sub> (1)	65 0.522	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

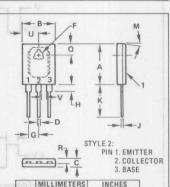
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	0 IC	1.92	°C/W

(1) Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (To	c = 25°C unless otherwise noted)
--------------------------------	----------------------------------

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	1 0	CERM	¥	
Collector-Emitter Breakdown Voltage (2) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	BVCEO	50	生	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 50 Vdc, I <sub>E</sub> = 0)	СВО	-	0.1	mAdc
$(V_{CB} = 50 \text{ Vdc}, I_{E} = 0, T_{C} = 150^{\circ}\text{C})$	ABSOA-	-	2.0	ching
Emitter Cutoff Current (VBE = 4.0 Vdc, IC = 0)	1EBO	_	1.0	mAdc

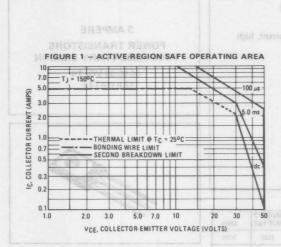
ON CHARACTERISTICS				
DC Current Gain (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	phe	25	100	xino
Base-Emitter Voltage (IC = 2.0 Adc, VCE = 2.0 Vdc)	VBE	_	1.2	Vdc



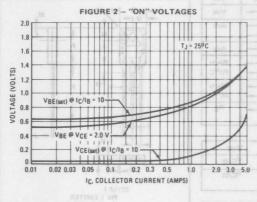
	MILLIN	IETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	16.13	16.38	0.635	0.645	
В	12.57	12.83	0.495	0.505	
C	3.18	3.43	0.125	0.135	
D	1.09	1.24	0.043	0.049	
F	3.51	3.76	0.138	0.148	
G	4.22	BSC	0.16	6 BSC	
Н	2.67	2.92	0.105	0.115	
J	0.813	0.864	0.032	0.034	
K	15.11	16.38	0.595	0.645	
M	90	TYP	90	TYP =	
0	4.70	4.95	0.185	0.195	
R	1.91	2.16	0.075	0.085	
U	6.22	6.48	0.245	0.255	
V	2.03	_	0.080	1000	

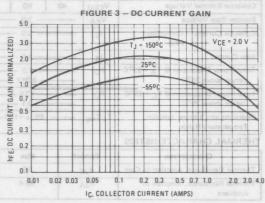
CASE 90-05 TO-127

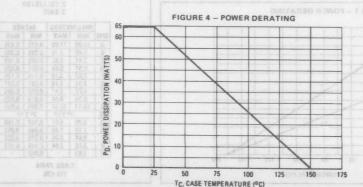
(2) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on  $T_{J(pk)}$  = 150°C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.









## COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

. . . designed for low power audio amplifier and low current, high speed switching applications.

Collector-Emitter Sustaining Voltage —

VCEO(sus) = 40 Vdc - MJE170, MJE180

= 60 Vdc - MJE171, MJE181

= 80 Vdc - MJE172, MJE182

DC Current Gain —

h<sub>FE</sub> = 30 (Min) @ I<sub>C</sub> = 0.5 Adc

Current-Gain - Bandwidth Product -

f<sub>T</sub> = 50 MHz (Min) @ I<sub>C</sub> = 100 mAdc

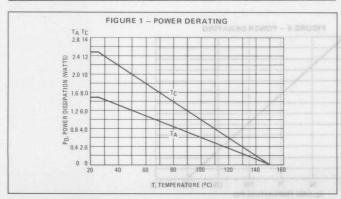
Annular Construction for Low Leakages —
 ICBO = 100 nA (Max) @ Rated VCB

#### MAXIMUM RATINGS

Rating	Symbol	MJE170 MJE180	MJE171 MJE181	MJE172 MJE182	Unit
Collector-Base Voltage	V <sub>CB</sub>	60	80	100	Vdc
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	— 7.0 —		Vdc
Collector Current - Continuous Peak	¹c	-	— 3.0 — — 6.0 —		Adc
Base Current	IB	4	<u> </u>	-	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD		— 1.5 — — 0.012 -		Watts W/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		— 12.5 — — 0.1 —		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +15	0	°C

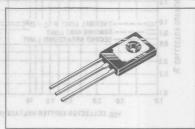
#### THERMAL CHARACTERISTICS

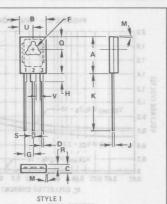
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	10	°C/W
Thermal Resistance, Junction to Ambient	θЈА	83.4	°C/W



# 3 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

40-60-80 VOLTS 12.5 WATTS





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

	MILLIM	ETERS	INC	HES		
DIM	MIN	MAX	MIN	MAX		
Α	10.80	11.05	0.425	0.435		
В	7.49	7.75	0.295	0.305		
C	2.41	2.67	0.095	0.105		
D	0.51	0.66	0.020	0.026		
F	2.92	3.18	0.115	0.125		
G	2.31	2.46	0.091	0.097		
H	1.27	2.41	0.050	0.095		
J	0.38	0.64	0.015	0.025		
K	15.11	16.64	0.595	0.655		
M	3	30 TYP		YP		
0	3.76	4.01	0.148	0.158		
R	1.14	1.40	0.045	0.055		
S	0.64	0.89	0.025	0.035		
U	3.68	3.94	0.145	0.155		
V	1.02	-	0.040	-		
	CASE 77-04					

TO-126

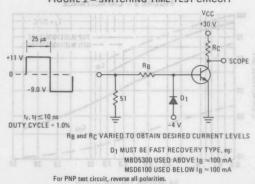
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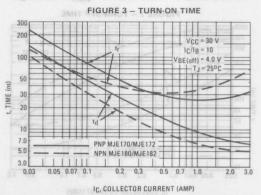
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					5,0
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)	MJE 170, MJE 180 MJE 171, MJE 181 MJE 172, MJE 182	VCEO(sus)	40 60 80		Vdc
Collector Cutoff Current $(V_{CB} = 60 \text{ Vdc}, I_{E} = 0)$ $(V_{CB} = 80 \text{ Vdc}, I_{E} = 0)$ $(V_{CB} = 100 \text{ Vdc}, I_{E} = 0)$ $(V_{CB} = 100 \text{ Vdc}, I_{E} = 0)$ $(V_{CB} = 60 \text{ Vdc}, I_{E} = 0, T_{C} = 150^{\circ}\text{C})$ $(V_{CB} = 80 \text{ Vdc}, I_{E} = 0, T_{C} = 150^{\circ}\text{C})$ $(V_{CB} = 100 \text{ Vdc}, I_{E} = 0, T_{C} = 150^{\circ}\text{C})$	MJE170, MJE180 MJE171, MJE181 MJE172, MJE182 MJE170, MJE180 MJE171, MJE181 MJE172, MJE182	ICBO	- 5.0	0.1 0.1 0.1 0.1 0.1 0.1	μAdc mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 7.0 Vdc, I <sub>C</sub> = 0)	(gre) 2181	IEBO	_	0.1	μAdc
ON CHARACTERISTICS	AFE OFERATING AREA	ive-sector s	TOA		
DC Current Gain  (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 1.0 Vdc)  (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)  (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 1.0 Vdc)  Collector-Emitter Saturation Voltage  (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc)	10 10 10 10 10 10 10 10 10 10 10 10 10 1	hFE VCE(sat)	50 30 12	250	Vdc
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 150 mAdc) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 600 mAdc)	0.1 %		25/2	0.9	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 150 mAdc) (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 600 mAdc)	0.00	V <sub>BE</sub> (sat)	DET THE SECOND	1.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	800,2	V <sub>BE</sub> (on)	AKIOWA LIMITED LY BELOW	86 USOD33	Vdc
YNAMIC CHARACTERISTICS	0.02	111/4	res (1) SUM	N USTAN	1.02
Current-Gain — Bandwidth Product (1) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1	0 MHz)	out fr oa	50	8.8 9.8 63	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	MJE170/MJE172 MJE180/MJE182	C <sub>ob</sub> (81.10)	n saarsey astro Ibest Tewon er		pF

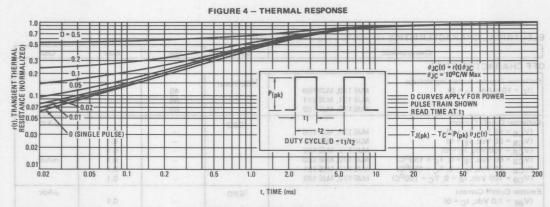
#### FIGURE 2 - SWITCHING TIME TEST CIRCUIT

tue, thernal limitations will reduce the power that can be to values loss than the limitations insposed by second bot

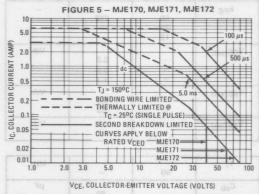
(1) fT = |hfe | • ftest | A A and I made at most be shallowed year



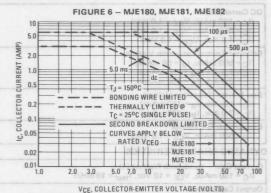




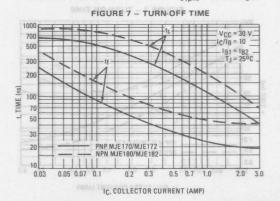
#### **ACTIVE-REGION SAFE OPERATING AREA**

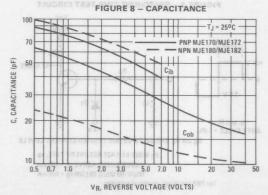


There are two limitations on the power handling ability of a transistor — average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figures 5 and 6 is based on  $T_{J(pk)} = 150^{\rm OC}$ ;  $T_C$  is

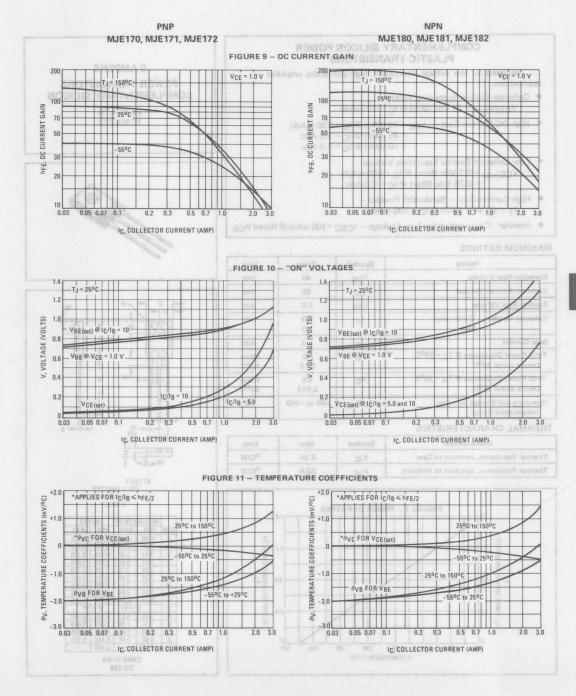


variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 150^{\rm O}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperature, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.











## COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low voltage, low-power, high-gain audio amplifier applications.

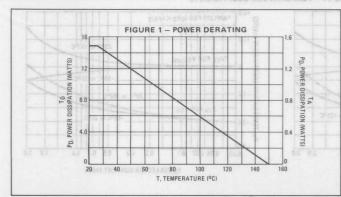
- Collector-Emitter Sustaining Voltage —
   VCEO(sus) = 25 Vdc (Min) @ IC = 10 mAdc
- High DC Current Gain hFE = 70 (Min) @ IC = 500 mAdc
   = 45 (Min) @ IC = 2.0 Adc
   = 10 (Min) @ IC = 5.0 Adc
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.3 Vdc (Max) @ I<sub>C</sub> = 500 mAdc
   = 0.75 Vdc (Max) @ I<sub>C</sub> = 2.0 Adc
- High Current-Gain Bandwidth Product —
   f<sub>T</sub> = 65 MHz (Min) @ I<sub>C</sub> = 100 mAdc
- Annular Construction for Low Leakage ICBO = 100 nAdc@ Rated VCB

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	VCB	40	Vdc
Collector-Emitter Voltage	VCEO	25	Vdc
Emitter-Base Voltage	VEB	8.0	Vdc
Collector Current — Continuous Peak	lc	5.0 10	Adc
Base Current	IB	1.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	15 0.12	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1.5 0.012	Watts W/OC
Operating and Storage Junction Temperature Range	TJ,Tstg	-65 to +150	°C

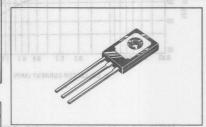
#### THERMAL CHARACTERISTICS

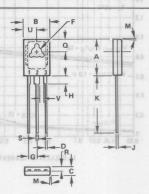
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	8.34	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	83.4	°C/W



# 5 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

25 VOLTS 15 WATTS





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

	MILLIN	IETERS	INC	HES	
IM	MIN	MAX	MIN	MAX	
A	10.80	11.05	0.425	0.435	
В	7.49	7.75	0.295	0.305	
C	2.41	2.67	0.095	0.105	
D	0.51	0.66	0.020	0.026	
F	2.92	3.18	0.115	0.125	
G	2.31	2.46	0.091	0.097	
H	1.27	2.41	0.050	0.095	
J	0.38	0.64	0.015	0.025	
K	15.11	16.64	0.595	0.655	
VI	3	O TYP	30 T	3º TYP	
0	3.76	4.01	0.148	0.158	
R	1.14	1.40	0.045	0.055	
S	0.64	0.89	0.025	0.035	
U	3.68	3.94	0.145	0.155	
V	1.02	83731	0.040	-	

3

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

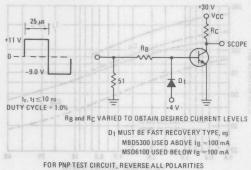
Characteristic	Symbol	Min	Max	Unit
DFF CHARACTERISTICS	- manufacture and a second		E di la la co	0.7
Collector-Emitter Sustaining Voltage (1) (IC = 10 mAdc, IB = 0)	VCEO(sus)	25		Vdc
Collector Cutoff Current ( $V_{CB} = 40 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 40 \text{ Vdc}$ , $I_E = 0$ , $T_J = 125^{\circ}\text{C}$ )	СВО		100 100	nAdc μAdc
Emitter Cutoff Current (VBE = 8.0 Vdc, IC = 0)	IEBO		100	nAdc
N CHARACTERISTICS OF THE STATE			O CHOOLE RUISE)	Z   co.o
DC Current Gain (1) (I <sub>C</sub> = 500 mAdc, $V_{CE}$ = 1.0 Vdc) (I <sub>C</sub> = 2.0 Adc, $V_{CE}$ = 1.0 Vdc) (I <sub>C</sub> = 5.0 Adc, $V_{CE}$ = 2.0 Vdc)	0.1 8.0	70 45 10	180	0.020.01
Collector-Emitter Saturation Voltage (1) ( $I_C = 500 \text{ mAdc}$ , $I_B = 50 \text{ mAdc}$ ) ( $I_C = 2.0 \text{ Adc}$ , $I_B = 200 \text{ mAdc}$ ) ( $I_C = 5.0 \text{ Adc}$ , $I_B = 1.0 \text{ Adc}$ )	VCE (sat)	- 10086	0.3 0.75 1.8	Vdc
Base-Emitter Saturation Voltage (1) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 1.0 Adc)	V <sub>BE</sub> (sat)	TIEFE	2.5	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	V <sub>BE(on)</sub>		1.6	Vdc
YNAMIC CHARACTERISTICS	1//	THE THE	als I	0.8
Current-Gain — Bandwidth Product (2) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)	/fT/	65	3º081 = [T	MHz
Output Capacitance	Cob	3761 - 31 0 0	STAND YOURSET -	pF

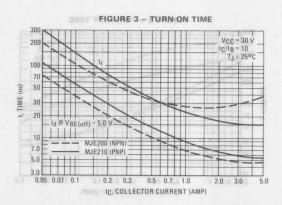
MJE200

MJE210

(1) Pulse test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\approx$  2.0%. (2) f<sub>T</sub> =  $\frac{1}{10}$  f<sub>Est</sub>

#### FIGURE 2 - SWITCHING TIME TEST CIRCUIT





80

120



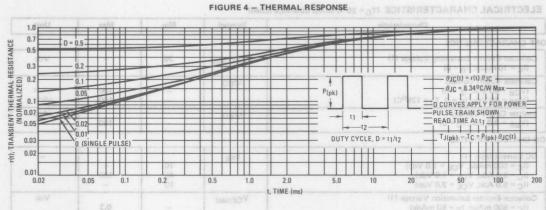
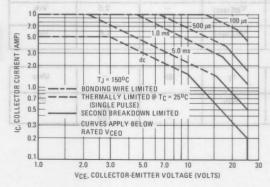


FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

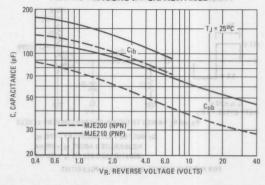
The data of Figure 5 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided TJ(pk)  $\le 150^{\rm o}$ C. TJ(pk) may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



FIGURE 6 - TURN-OFF TIME



#### FIGURE 7 - CAPACITANCE



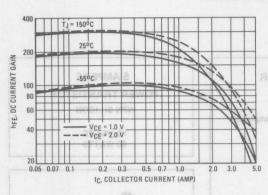
MOTOROLA

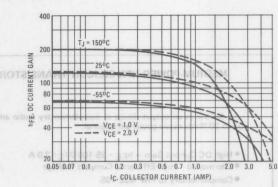
PNP

**MJE210** 

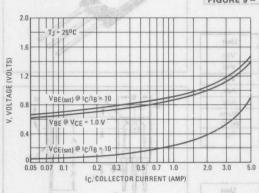
#### NPN **MJE200**

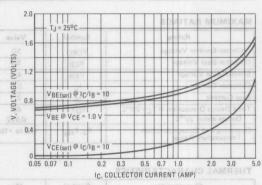
#### FIGURE 8 - DC CURRENT GAIN



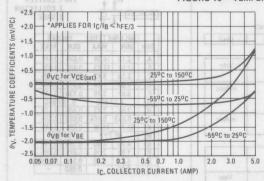


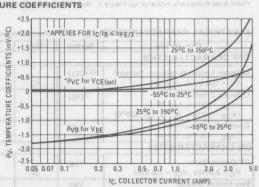
#### FIGURE 9 - "ON" VOLTAGE





#### FIGURE 10 - TEMPERATURE COEFFICIENTS





. for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain hFE = 25-100 @ IC = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE 105

5 AMPERE

**POWER TRANSISTOR** 

NPN SILICON

50 VOLTS 65 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	50	Vdc
Collector-Base Voltage	V <sub>CB</sub>	50	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current	I <sub>C</sub>	5.0	Adc
Base Current	I <sub>B</sub>	2.5	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PDT	65 0.522	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

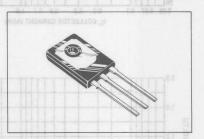
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	0 JC	1.92	°C/W

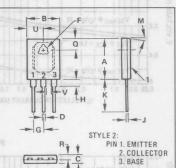
†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		0.7	1 6	
Collector-Emitter Breakdown Voltage‡ (IC = 100 mAdc, IB = 0)	BV <sub>CEO</sub> ‡	50		Vdc
Collector Cutoff Current (VCB = 50 Vdc, IE = 0) (VCB = 50 Vdc, IE = 0, TC = 150°C)	ICBO	- 8.0-	0.1	mAdc
Emitter Cutoff Current (VBE = 4.0 Vdc, I <sub>C</sub> = 0)	IEBO	2.1-	1.0	mAdc
ON CHARACTERISTICS		0.5-		19500
DC Current Gain (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	hFE	25	100	0.8
Base-Emitter Voltage (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	VBE		1.2	Vdc

‡Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.





	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
Α	16.13	16.38	0.635	0.645
В	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.23	BSC	0.16	6 BSC
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90	TYP	90	TYP
0	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
٧	2.03	0.47	0.080	-

CASE 90-05 TO-127

1.0

2.0 3.0



5.0 7.0

10 VCE, COLLECTOR EMITTER VOLTAGE (VOLTS)

#### Note 1:

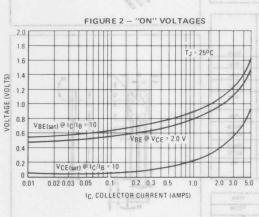
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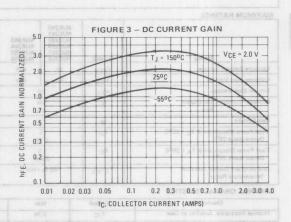
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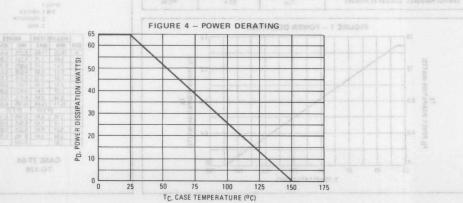
There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to  $10^{\circ}$ , provided  $T_{J(pk)} \leq 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. · High Corrent Gain Bundwidth Product

@ Annular Construction for Low Leakages







3-1101



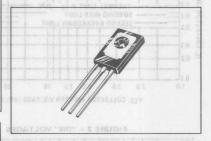
### COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low power audio amplifier and low-current, high-speed switching applications.

- High Collector-Emitter Sustaining Voltage –
   VCEO(sus) = 80 Vdc (Min) MJE240/2, MJE250/2
   = 100 Vdc (Min) MJE243/4, MJE253/4
- High DC Current Gain @ I<sub>C</sub> = 200 mAdc
   hFE = 40-200 MJE240, MJE250
   = 40-120 MJE241,243, MJE251,253
   = 25 (Min) MJE242,44, MJE252,54
- Low Collector-Emitter Saturation Voltage —
   VCE(sat) = 0.3 Vdc (Max) @ IC = 500 mAdc
  - High Current Gain Bandwidth Product fT = 40 MHz (Min) @ IC = 100 mAdc
  - Annular Construction for Low Leakages
     ICBO = 100 nAdc (Max) @ Rated VCB

4 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
80, 100 VOLTS

15 WATTS

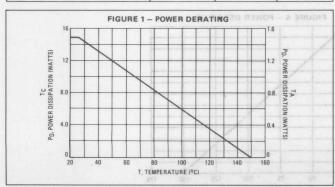


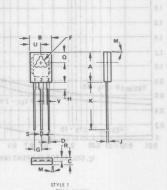
MAXIMUM RATINGS

- OC CURRENT GAIN  To 150°C gains VCE=28V -	Symbol	MJE240 MJE241 MJE242 MJE250 MJE251 MJE252	MJE243 MJE244 MJE253 MJE254	Unit
Collector-Emitter Voltage	VCEO	80	100	Vdc
Collector-Base Voltage	VCB	80	100	Vdc
Emitter-Base Voltage	VEB	7.	0	Vdc
Collector Current - Continuous Peak	lc	4.	-	Adc
Base Current	I <sub>B</sub>	1.	0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		5	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD		5	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	+150	°C

#### THERMAL CHARACTERISTICS

Characteristic TABREUS HO	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	8.34	°C/W
Thermal Resistance, Junction to Ambient	θЈΑ	83.4	°C/W





PIN 1. EMITTER 2. COLLECTOR 3. BASE

	MILLIMETERS		INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	30 TYP		30 TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-

CASE 77-04 TO-126

Max

Unit

Vdc

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) Symbol Characteristic Min OFF CHARACTERISTICS Collector-Emitter Sustaining Voltage (I<sub>C</sub> = 10 mAdc, I<sub>B</sub> = 0) VCEO(sus) MJE240, MJE241, MJE242, 80 MJE250,MJE251,MJE252 100 MJE243,MJE244

	MJE253,MJE254	The state of the s	The same of the sa	THE RELEASE DESCRIPTION	the property of
Collector Cutoff Current (VCB = 80 Vdc, IE = 0)	MJE240,MJE241,MJE242,	СВО	Total Comment	0.1	μAdc
(V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)	MJE250,MJE251,MJE252 MJE243,MJE244,			0.1	
(V <sub>CE</sub> = 80 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 125°C)	MJE253,MJE254, MJE240,MJE241,MJE242 MJE250,MJE251,MJE252,			0.150.6	mAdc
(V <sub>CE</sub> = 100 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 125°C)	MJE243,MJE244 MJE253,MJE254			0.100	1.03
Emitter Cutoff Current (VBE = 7.0 Vdc, IC = 0)		1EBO		0.1	μAdc
ON CHARACTERISTICS	01 0.0 0.5	U.A. GAL	5.0	100 2000	20.0

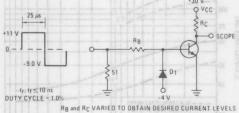
ON	CHARACTERISTICS
DC	Current Gain

(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	MJE242,MJE252 MJE244,MJE254 MJE240,MJE250	0,00	10	2m D. (	2.0
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc) (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 100 mAdc)  MJE241,MJE251, MJE251,MJE251, MJE251,MJE251, MJE251,MJE251, MJE251,MJE251, MJE251,MJE251, MJE251,MJE251,MJE251, MJE251,MJE251,MJE251, MJE251,MJE2		VCE(sat)	- III	0.3	Vdc
	JE243,MJE253 { JE240, MJE250	7/1	ED 9 TC - 26 1++++ 1++++++++++++++++++++++++++++++	8.0 PULSE	0.2
Base-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 200 mAdc)	mani usustupisa	VRE(sat)		1.8	Vdc
Base-Emitter On Voltage (IC = 500 mAdc, VCF = 1.0 Vdc)	nent zaul sevies	V <sub>BE</sub> (on)	THE SACTOR	1.5	Vdc

#### **DYNAMIC CHARACTERISTICS**

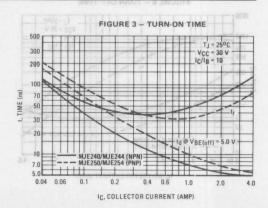
DINAMIC CHARACTERISTICS		30 00 00	nt or ny	02 05 05	0.1
Current-Gain — Bandwidth Product (IC = 100 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 10	MHz)	a <sup>f</sup> Tow sax	40 A0	VOE COLLECT	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	MJE240/MJE244 MJE250/MJE254	C <sub>ob</sub>	_	50 70	pF

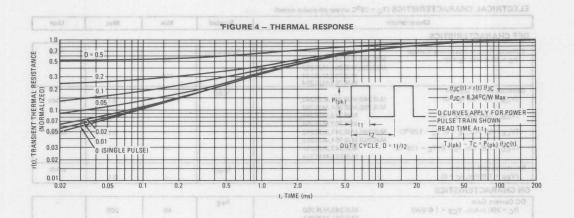
# FIGURE 2 - SWITCHING TIME TEST CIRCUIT

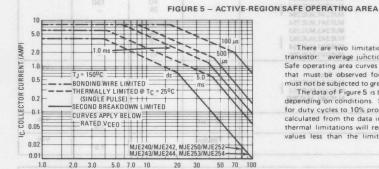


D1 MUST BE FAST RECOVERY TYPE, eg MBD5300 USED ABOVE IB ~100 mA MSD6100 USED BELOW IB - 100 mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES





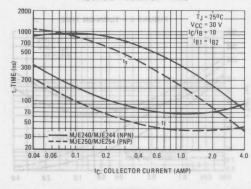


There are two limitations on the power handling ability of a transistor—average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

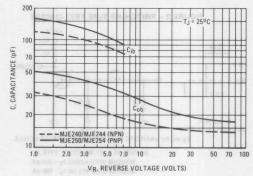
The data of Figure 5 is based on  $T_{J(pk)}$  =  $150^{\circ}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}$   $\lesssim 150^{\circ}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



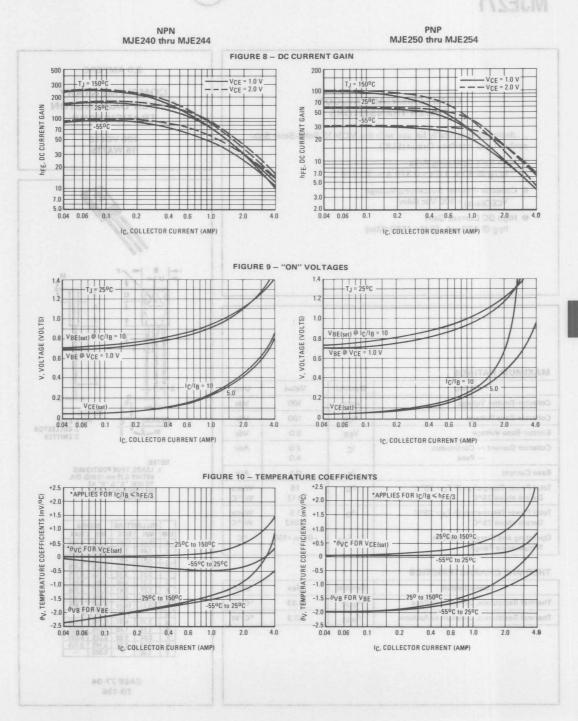
VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)



#### FIGURE 7 - CAPACITANCE



## MJE240 thru MJE244, NPN, MJE250 thru MJE254, PNP



#### COMPLEMENTARY SILICON POWER TRANSISTORS

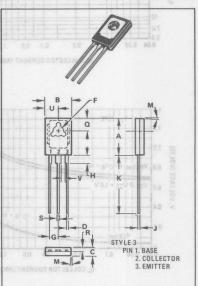
...designed specifically for use with the MC3419 Solid-State Subscriber Loop Interface Circuit (SLIC).

- High Safe Operating Area
   IS/B @ 40 V, 1.0 s = 0.375 A TO-126
- Collector-Emitter Sustaining Voltage
   VCEO(sus) = 100 Vdc (Min)
- High DC Current Gain
   hFE @ 120 mA, 10 V = 1500 (Min)

2.0 AMPERE

## POWER DARLINGTON TRANSISTORS

100 VOLTS 15 WATTS



NOTES:
1. LEADS, TRUE POSITIONED WITHIN 0.25 mm (0.010) DIA. TO DIM. "A" & "B" AT MAXIMUM MATERIAL CONDITION.

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	O TYP	30 T	YP
0	3.76	4.01	0.148	0.158
B	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
٧	1.02	=	0.040	-

CASE 77-04 TO-126

#### MAXIMUM RATING

MAXIMUM RATINGS		40 -	
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	100	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current — Continuous — Peak	IC	2.0 4.0	Adc
Base Current	I <sub>B</sub>	0.1 R 19W	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	15 0.12	Watts W/°C
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.5 0.012	Watts W/°C
Operating and Storage Junction	TJ, T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

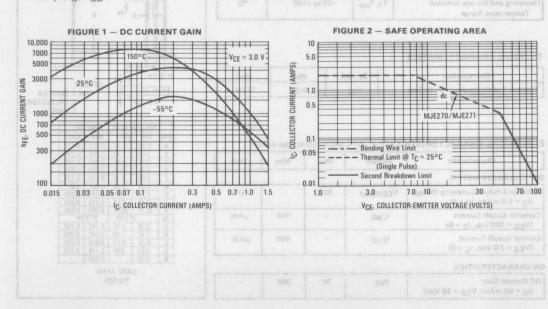
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	8.33	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta}$ JA	83.3	°C/W



#### FLECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)		Nai	VCEO(sus)	100 IGENI DIT	PLAS	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 100 Vdc, I <sub>B</sub> = 0)			PO ICEO /AF	LICON T	2 1.0	mAdc
Collector Cutoff Current (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)		anoit	ICBO	Eage general	E.0	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)			IEBO	-	0.1	mAdc
SECOND BREAKDOWN	ands Tirest	Inemquip	B betaregOeni.	ormerless, t	e for Transf	9 Suitable
Second Breakdown Collector Current with Base Form (V <sub>CE</sub> = 40 Vdc, t = 1.0 s, non-repetitive)	ward Biased	Dissipation	IS/b	on¶ 375 out	oped —Cons in Reliabilit	
ON CHARACTERISTICS (1)						
DC Current Gàin (I <sub>C</sub> = 20 mAdc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 120 mAdc, V <sub>CE</sub> = 10 Vdc)			hFE	500 1500	_	-
Collector-Emitter Saturation Voltage ( $I_C$ = 20 mAdc, $I_B$ = 0.2 mAdc) ( $I_C$ = 120 mAdc, $I_B$ = 1.2 mAdc)			VCE(sat)	=	2.0 3.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 120 mAdc, V <sub>CE</sub> = 10 Vdc)		euls V	VBE(on)		2.0	Vdc
DYNAMIC CHARACTERISTICS	obV V	900	OsoV		agettoV 16	tector-Emitt
Current Gain — Bandwidth Product (2) (I <sub>C</sub> = 0.05 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	Vác	3.0 500	ft 83V	6.0	stage rc = Continue	MHz MHz
NOTES: (1) Pulse Test: Pulse Width $\leq 300 \ \mu s$ , Duty Cycle $\leq 2.0\%$ .	SHOW -	20	d <sub>d</sub>	- 25°C	sinstion P To	tal Power Dis Derate above

(2) fT = | hfe | • ftest





## PLASTIC MEDIUM POWER NPN SILICON TRANSISTOR

... useful for high-voltage general purpose applications.

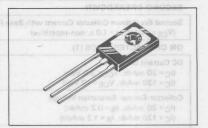
- Suitable for Transformerless, Line-Operated Equipment
- Thermopad Construction Provides High Power Dissipation Rating to the for High Reliability

#### 0.5 AMPERE

POWER TRANSISTOR

NPN SILICON

300 VOLTS



#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	300	Vdc
Emitter-Base Voltage	VEB	3.0	Vdc
Collector Current - Continuous	1c	500	mAdo
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	20 0.16	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

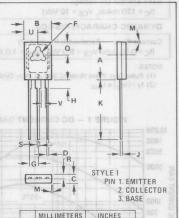
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	6.25	°C/W

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	- Second Bracket			
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 1.0 mAdc, Ig = 0)	VCEO(sus)	300	- 6.1	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 300 Vdc, I <sub>E</sub> = 0)	СВО	-	100	μAdc
Emitter Cutoff Current (VEB = 3.0 Vdc, IC = 0)	IEBO	-	100	μAdc

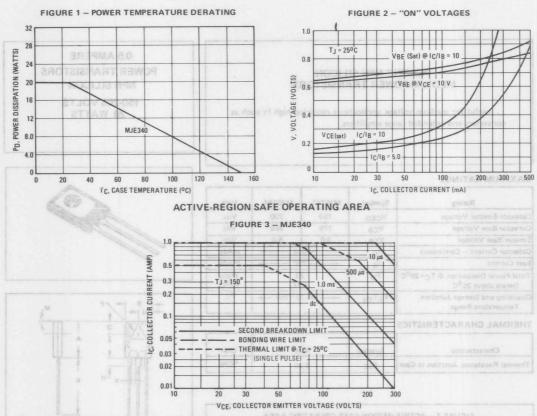
#### ON CHARACTERISTICS

DC Current Gain	hFE	30	240	
(I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 10 Vdc)				



	MILLIN	ETERS	INC	HES
MID	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	0 TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-

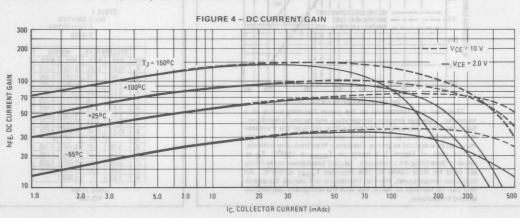
CASE 77-04 TO-126



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating

area curves indicate  $I_C \cdot V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





PIGURE 1 - POWER TEMPERATURE DERATING

#### PLASTIC NPN SILICON MEDIUM-POWER TRANSISTORS

... useful for medium voltage applications requiring high fr such as converters and extended range amplifiers.

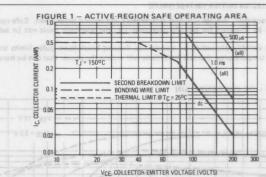
05 AMPERE POWER TRANSISTORS NPN SILICON 150-200 VOLTS 20 WATTS

#### MAXIMUM BATINGS

(Am) TM39NUS NOT33	1100 01			
Rating	Symbol	MJE341	MJE344	Unit
Collector-Emitter Voltage	VCEO	150	200	Vdc
Collector-Base Voltage	VCB	175	200	Vdc
Emitter-Base Voltage	VEB	3.0	5.0	Vdc
Collector Current - Continuous	1c	- 5	00	mAdc
Base Current	IB /	2	50 —	mAdc
Total Power Dissipation @ T <sub>C</sub> =25°C Derate above 25°C	PD	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.16	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		to +150 —	°C

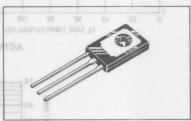
#### THERMAL CHARACTERISTICS

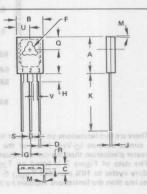
	1	TIMIL 38 IN 6KI	0M0B
Characteristic	Symbol	Max Max	Unit
Thermal Resistance, Junction to Case	θЈС	6.25	°C/W



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{o}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





PIN 1. EMITTER 2. COLLECTOR

	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	30 TYP		YP
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
٧	1.02	-	0.040	-

CASE 77-04 TO-126

Output Capacitance

Small-Signal Current Gain

(VCB = 20 Vdc, IE = 0, f = 100 kHz)

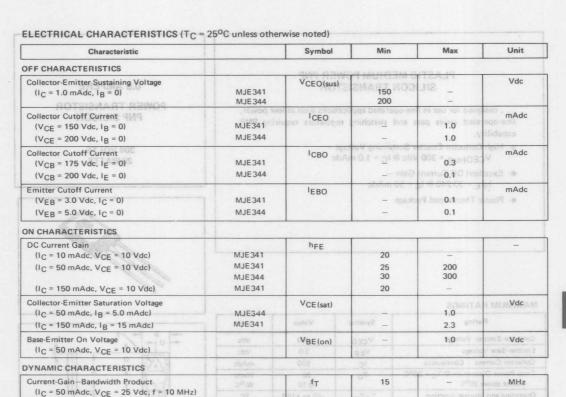
(IC = 50 mAdc, VCE = 10 Vdc, f = 1.0 kHz)

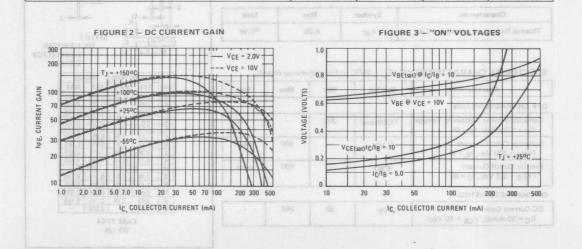
pF

15

25







Cob

hfe

#### PLASTIC MEDIUM POWER PNP SILICON TRANSISTOR

. . . designed for use in line-operated applications such as low power, line-operated series pass and switching regulators requiring PNP capability.

- High Collector-Emitter Sustaining Voltage —
   VCEO(sus) = 300 Vdc @ IC = 1.0 mAdc
- Excellent DC Current Gain hFE = 30-240 @ IC = 50 mAdc
- Plastic Thermopad Package

## 0.5 AMPERE

300 VOLTS



#### MAXIMUM RATINGS

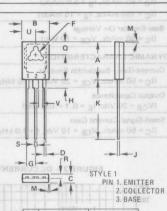
A A			ALC: N. C. C. L. C.
Rating 8.5	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	(no) 300	Vdc
Emitter-Base Voltage	VEB	3.0	Vdc
Collector Current - Continuous	1c	500	mAdo
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	ar PD	20 0.16	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	JDIE θJC	6.25	°C/W

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

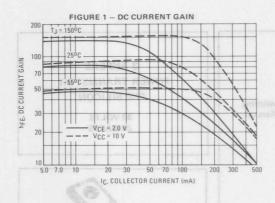
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	3gV	0.0	1000	DIT:
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	300	- 176 177 177 177 177 177 177 177 177 177	Vdc
Collector Cutoff Current (VCB = 300 Vdc, IE, = 0)	ГСВО	90V	100	μAdo
Emitter Cutoff Current (VEB = 3.0 Vdc, IC = 0)	IEBO		100	μAdo
ON CHARACTERISTICS	20 39	01	(5)	200 200 5
DC Current Gain (IC = 50 mAdc, VCE = 10 Vdc)	100 hFE	30	240	-

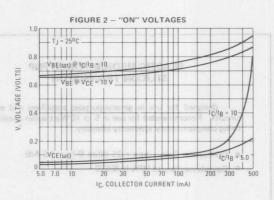


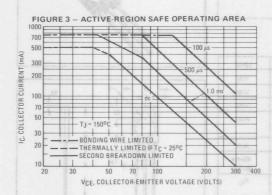
	MILLIM	ETERS	INC	HES
MID	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	O TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	1 104	0.040	-

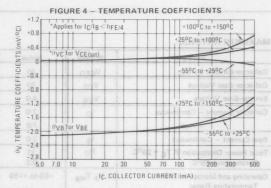
TO-126





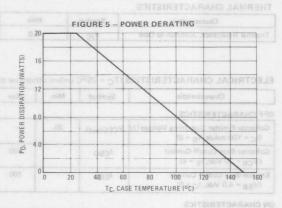






There are two limitations on the power handling ability of a transitor: average junction temperature and second breakdown. Safe operating area curves indicate  $1_{\rm C} - V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on  $T_{J(pk)}=150^{\rm o}{\rm C};\,T_{\rm C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\rm o}{\rm C}.$  At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakfalves.





#### PLASTIC MEDIUM-POWER PNP SILICON TRANSISTOR

designed for use in general-purpose amplifiers and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain hFE = 25 (Min) @ IC = 1.0 Adc
- Complementary to NPN MJE520

## 3 AMPERE POWER TRANSISTOR PNP SILICON

30 VOLTS 25 WATTS

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	30	Vdc
Collector-Base Voltage	V <sub>CB</sub>	30	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current - Continuous	1c	3.0	Adc
- Peak	agV set	7.0	
Base Current - Continuous	I <sub>B</sub>	2.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	25 0.2	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	5.0	°C/W

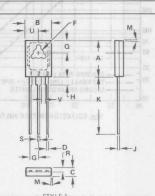
#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				eldsiyav
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	V <sub>CEO(sus)</sub>	30	#E-	Vdc
Collector-Base Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0)	ГСВО		100	μAdc
Emitter-Base Cutoff Current (VEB = 4.0 Vdc, IC = 0)	I <sub>EBO</sub>	05 - 00	100	μAdc

#### ON CHARACTERISTICS

DC Current Gain	hFE	25	 -
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)			

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.

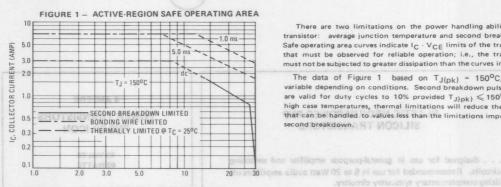


PIN 1. EMITTER 2. COLLECTOR 3. BASE

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	OTYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-

TO-126

MOTOROLA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C \cdot V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J)pk} \le 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

 DC Corront Gain - hpg = 40 (Min) @ 10 = 1.0 Ado MJE371 is Complementary to NPN MJE521

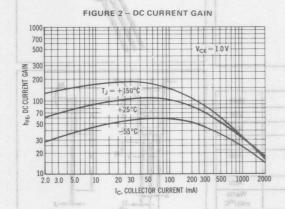
V<sub>CE (sot)</sub> @ I<sub>C</sub>/I<sub>B</sub> = 10

20 30 50 100

IC. COLLECTOR CURRENT (mA)

10





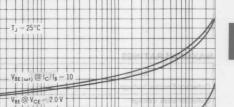
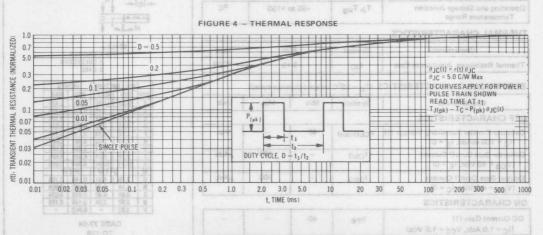


FIGURE 3 - "ON" VOLTAGE



(VOLTS)

VOLTAGE (

0.3

#### PLASTIC MEDIUM-POWER PNP SILICON TRANSISTORS

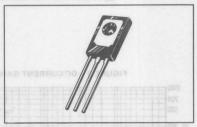
. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 20 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain hff = 40 (Min) @ IC = 1.0 Adc
- MJE371 is Complementary to NPN MJE521

#### 4 AMPERE

## POWER TRANSISTORS PNP SILICON

40 VOLTS 40 WATTS



3

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit	
Collector-Emitter Voltage	VCEO	40	Vdc	
Collector-Base Voltage	V <sub>CB</sub>	40	Vdc	
Emitter-Base Voltage	VEB	4.0	Vdc	
Collector Current — Continuous	¹c	4.0	Adc	
- Peak	(test) 3 P	8.0		
Base Current — Continuous	1 <sub>B</sub>	2.0	Adc	
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	40 320	Watts mW/OC	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C	

#### THERMAL CHARACTERISTICS

THE MINAL CHANACTEMISTICS	ali ole alientele e coltabi		
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ,IC	3.12	°C/W

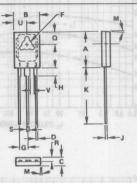
#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS			124	
Collector-Emitter Sustaining Voltage (1) (IC = 100 mAdc, IB = 0)	VCEO(sus)	40	100	Vdc
Collector-Base Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	СВО	1-00	100	μAdo
Emitter-Base Cutoff Current (VEB = 4.0 Vdc, IC = 0)	IEBO	11-11	100	μAdc

#### ON CHARACTERISTICS

DC Current Gain (1)	hee	40	 -
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)			

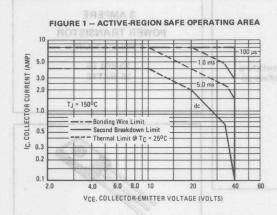
(1) Pulse Test: Pulse Width≤ 300 µs Duty Cycle≤ 2.0%.



PIN 1. EMITTER
2. COLLECTOR
3. BASE

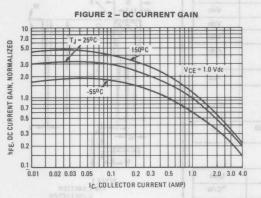
-	MILLIM	ETERS	INCHES	
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	30 TYP		30 T	YP
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
٧	1.02	-	0.040	-

TO-126



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> - V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 150^{\circ}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



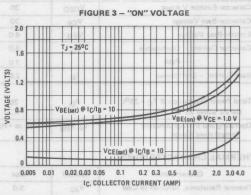
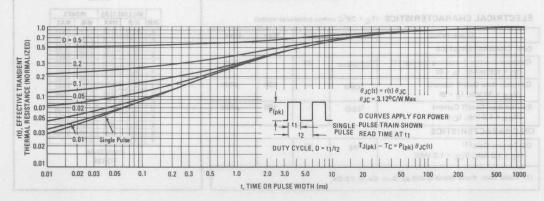


FIGURE 4 - THERMAL RESPONSE





#### PLASTIC MEDIUM-POWER NPN SILICON TRANSISTOR

. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain hFE = 25 (Min) @ IC = 1.0 Adc
- Complementary to PNP MJE370

3 AMPERE
POWER TRANSISTOR
NPN SILICON

30 VOLTS 25 WATTS

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	30	Vdc
Collector-Base Voltage	VCB	30	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current – Continuous	3º IC	3.0	Adc
- Peak		7.0	
Base Current — Continuous	IB	2.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	P <sub>D</sub>	25 0.2	Watts W/OC
Operating and Storage Junction Temperature Range	TJ, T <sub>stg</sub>	-65 to +150	°C

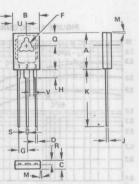
#### THERMAL CHARACTERISTICS

0.40.0 0.5 Characteristic 1.0	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	5.0	°C/W

#### **ELECTRICAL CHARACTERISTICS** ( $T_C = 25^{\circ}C$ unless otherwise noted)

Symbol	Min	Max	Unit
VCEO(sus)	30		Vdc
СВО	11-11	100	μAdc
IEBO		100	μAdc
POESE READ TO			
- MARKE SA	25	YTUG-	
	VCEO(sus)	VCEO(sus) 30  CBO -	VCEO(sus)   30   -

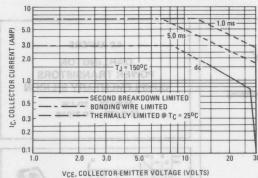




STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

MILLIN	IETERS	INC	HES
MIN	MAX	MIN	MAX
10.80	11.05	0.425	0.435
7.49	7.75	0.295	0.305
2.41	2.67	0.095	0.105
0.51	0.66	0.020	0.026
2.92	3.18	0.115	0.125
2.31	2.46	0.091	0.097
1.27	2.41	0.050	0.095
0.38	0.64	0.015	0.025
15.11	16.64	0.595	0.655
3	O TYP	30 T	YP
3.76	4.01	0.148	0.158
1.14	1.40	0.045	0.055
0.64	0.89	0.025	0.035
3.68	3.94	0.145	0.155
1.02	P. Perul	0.040	-
	MIN 10.80 7.49 2.41 0.51 2.92 2.31 1.27 0.38 15.11 3.76 1.14 0.64 3.68	10.80 11.05 7.49 7.75 2.41 2.67 0.51 0.66 2.92 3.18 2.31 2.46 1.27 2.41 0.38 0.64 15.11 16.64 30 TYP 3.76 4.01 1.14 1.40 0.64 0.89 3.68 3.94	MIN   MAX   MIN   10.80   11.05   0.425   7.49   7.75   0.295   2.41   2.67   0.095   0.51

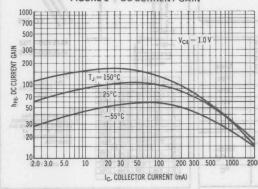




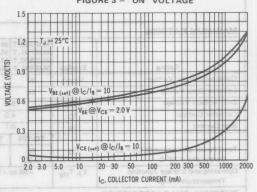
The data of Figure 1 based on  $T_{J(pk)}=150^{o}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $(T_{Jpk}) \lesssim 150^{o}C$ . At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $L_C \cdot V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

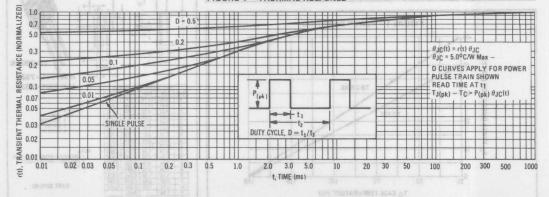
#### FIGURE 2 - DC CURRENT GAIN



#### FIGURE 3 - "ON" VOLTAGE



#### FIGURE 4 - THERMAL RESPONSE





#### PLASTIC DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general-purpose amplifier and low-speed switching applications.

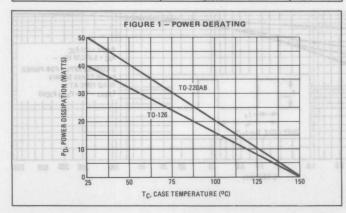
- High DC Current Gain —
   hFE = 2000 (Typ) @ IC = 2.0 Adc
- Monolithic Construction with Built-in Base-Emitter Resistors to Limit Leakage Muliplication
- Choice of Packages —
   TO126, MJE700 and MJE800 series
   TO220AB, MJE700T and MJE800T series

#### MAXIMUM RATINGS

Rating	Symbol	MJE701,T MJE800,T	MJE702,T MJE703,T MJE802,T MJE803,T	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current	lc	4	.0	Adc
Base Current	IB	0	.1	Adc
		TO-126	TO-220	MIT I
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	40 0.32	50 0.40	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to	+150	°C

#### THERMAL CHARACTERISTICS

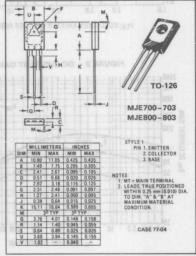
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC		°C/W
TO-126		3.13	
TO-220	5 286	2.50	T A REEL

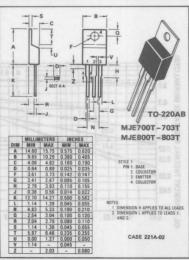


## 4.0 AMPERE

DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

40 WATT - TO-126 50 WATT - TO-220AB





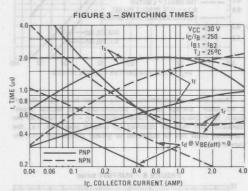
#### PNP MJE700,T thru MJE703,T NPN MJE800,T thru MJE803,T

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

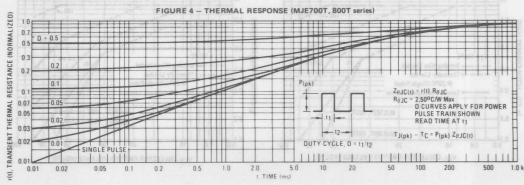
	Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS			2.1.7 (6)		
Collector-Emitter Breakdown Voltag	e (1) MJE700,T, MJE701,T, MJE800,T, MJE801,T MJE702,T, MJE703,T, MJE802,T, MJE803,T	BVCEO	60 80		Vdc
Collector Cutoff Current (VCE = 60 Vdc, I <sub>B</sub> = 0) (VCE = 80 Vdc, I <sub>B</sub> = 0)	MJE700,T, MJE701,T, MJE800,T, MJE801,T MJE702,T, MJE703,T, MJE802,T, MJE803,T	ICEO		100 100	μAdc
Collector Cutoff Current (VCB = Rated BVCEO, IE = 0) (VCB = Rated BVCEO, IE = 0, T	C = 100°C)	СВО		100 500	μAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	11-10-30	IEBO	- I	2.0	mAdc
ON CHARACTERISTICS	ster e augravium Hit				
DC Cyrrent Gain (1) $(I_C = 1.5 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$ $(I_C = 2.0 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$ $(I_C = 4.0 \text{ Adc}, V_{CE} = 3.0 \text{ Vdc})$	MJE700,T, MJE702,T, MJE800,T, MJE802,T MJE701,T, MJE703,T, MJE801,T, MJE803,T All devices	hFE	750 750 100	100 EH2 530	10.0
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 30 mAdc) (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 40 mAdc) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 40 mAdc)	e (1) MJE700,T, MJE702,T, MJE800,T, MJE802,T MJE701,T, MJE703,T, MJE801,T, MJE803,T All Device	VCE(sat)	evarte	2.5 2.8 3.0	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	MJE700,T, MJE702,T, MJE800,T, MJE802,T MJE701,T, MJE703,T, MJE801,T, MJE803,T All Devices	VBE(on)		2.5 2.5 3.0	Vdc
DYNAMIC CHARACTERISTICS	-15 100 5		200	49 11	1 10
Small-Signal Current Gain	= 1.0 MHz)	h <sub>fe</sub>	1.0	- 1	TF

# FIGURE 2 — SWITCHING TIMES TEST CIRCUIT Rg & Rc VARIED TO OBTAIN DESIRED CURRENT LEVELS O1, MUST BE FAST RECOVERY TYPES, e.g., MMD5300 USED BOVE 1g = 100 mA MSD6100 USED BELOW Ig = 100 mA TUT Approx 12 V For t<sub>q</sub> and t<sub>r</sub>, 0 1 is disconnected and V2 = 0, Rg and Rc are varied to obtain desired test currents.

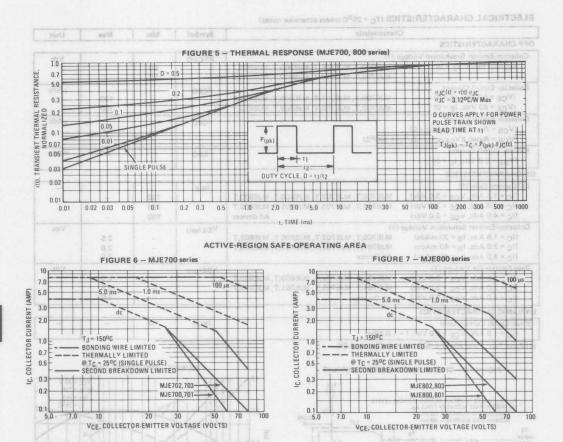
polarities and input pulses.



NPN MJESOO,T thru MJESOS,T

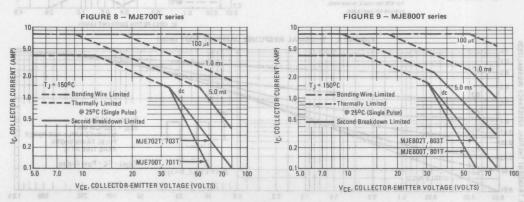






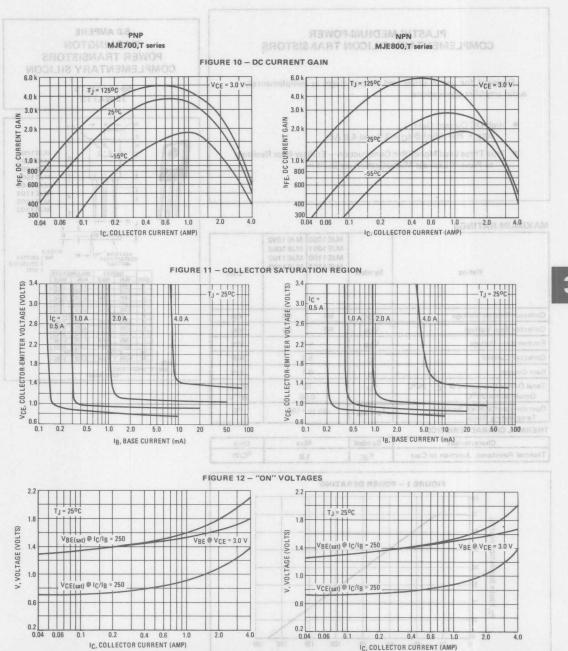
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\rm C}-V_{\rm CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 6 and 7 are based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}=150^{\circ}C$ ,  $T_{J(pk)}$  may be calculated from the data in Figure 4 or 5. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



MJE1100 thru MJE1103







## PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

Designed for use in driver and output stages in complementary audio amplifier applications.

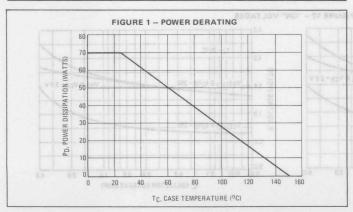
- High DC Current Gain –
   hFE = 750 (Min) @ I<sub>C</sub> = 3.0 and 4.0 Adc
- True Three Lead Monolithic Construction Emitter-Base Resistors to Prevent Leakage Multiplication are Built in.

**MAXIMUM RATINGS** 

Rating	Symbol	MJE1091	MJE1092 MJE1093 MJE1102 MJE1103	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current	I <sub>C</sub>	5.0		Adc
Base Current	I <sub>B</sub>	0.1		Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	70 0.56		Watts W/OC
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-55 to	+150	υС

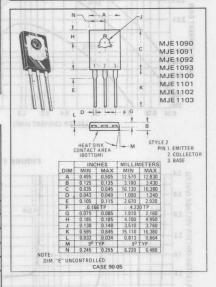
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	1.8	°C/W



# 5.0 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60-80 VOLTS 70 WATTS



IQ ZAS CURRENT (MA)

#### PNP, MJE1090 thru MJE1093 NPN, MJE1100 thru MJE1103

MJE1290 MJE1291 PNP MJE1660 MJE1661 NPN

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Ch	aracteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage <sup>(</sup> (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	MJE1090, MJE1091, MJE1100, MJE1101	BVCEO	60	_	Vdc
	MJE1092, MJE1093, MJE1102, MJE1103	-	80	-	
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, 1 <sub>B</sub> = 0)	MJE1090, MJE1091, MJE1100, MJE1101	ICEO	- 1	500	μAdc
(V <sub>CE</sub> = 40 Vdc, ( <sub>B</sub> = 0)	MJE1092, MJE1093, MJE1102, MJE1103	MARY SEV	MADURANCE DANS	500	
Collector Cutoff Current (VCB = Rated BVCEO, IE = 0) (VCB = Rated BVCEO, IE = 0, TC =		СВО	Ξ	0.2 2.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, I <sub>C</sub> = 0)	д зучениед аррисацеиз.	IEBO	SWOTEN 620	2.0	mAdc

#### ON CHARACTERISTICS (1)

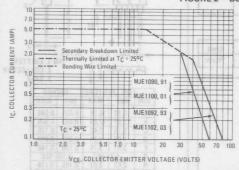
IN CHARACTERISTICS (1)			34	2/4 C1 - 3/1	
DC Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102	hFE Adc	750	High DC Cues	9
(I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		750	-1-	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 12 mAdc)	MJE1090, MJE1092, MJE1100, MJE1102	VCE (sat)	-	2.5	Vdc
(I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 16 mAdc)	MJE1091, MJE1093, MJE1101, MJE1103		-	2.8 2.8 2.4 TAR	MUMIXA
Base-Emitter On Voltage (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102	VBE (on)		2.5	Vdc
$(I_C = 4.0 \text{ Adc, } V_{CE} = 3.0 \text{ Vdc})$	MJE1091, MJE1093, MJE1101, MJE1103	Ven	-	2.5	oringen - E.n. ollegtor-Bar

#### DYNAMIC CHARACTERISTICS

Small-Signal Current Gain	Adc	e!	hfe	1.0	Duru ( <u>CDD-striet</u>	Calledior Cul
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 MHz)	Add	5.0	al I			Buss Current

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

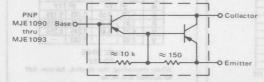
#### FIGURE 2 - DC SAFE OPERATING AREA

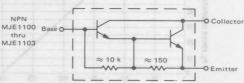


There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate. At high case temperatures, thermal limitations will reduce the

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

#### FIGURE 3 - DARLINGTON CIRCUIT SCHEMATIC







## COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

... designed for use in power amplifier and switching applications.

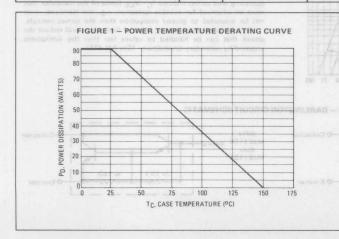
- High Collector Current –
   IC = 15 Adc
- High DC Current Gain –
   hFE = 10 (Min) @ I<sub>C</sub> = 15 Adc

#### MAXIMUM RATINGS

Rating	Symbol	MJE 1290 MJE 1660	MJE1291 MJE1661	Unit
Collector-Emitter Voltage	VCEO	40	60	Vdc
Collector-Base Voltage	VCB	40	60	Vdc
Emitter-Base Voltage	VEB	5	.0	Vdc
Collector Current-Continuous	lc	IC 15		Adc
Base Current	IB	5.0		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		90 72	Watts W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+150	°C

#### THERMAL CHARACTERISTICS

Characteristics Characteristics	Symbol	Max Max	Unit
Thermal Resistance, Junction to Case	θJC	1.39	°C/W



# 15 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

40-60 VOLTS 90 WATTS



	DVMANIC CHARL
B- F	M
- 0	Lob A G. C. Anti
Cirk a	1 17
WITH A DINVE	(1) Pulsa Till Pla
	A
1 2 3 1	1 1
TITT -	
	K
	VIII TO BE
D	1 0c 8
G B ST	YLE 2:
ACCURATION AND ADDRESS.	PIN 1. EMITTER
C	2. COLLECTOR
Lucer als	3. BASE

****	MILLIN	METERS	INC	CHES
DIM	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
В	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22	2 BSC	0.16	6 BSC
Н	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90	90 TYP		TYP
0	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
V	2.03	-	0.080	-

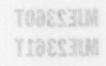
CASE 90-05 TO-127

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

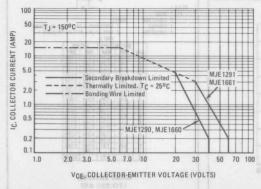
#### MJE1290, MJE1291 PNP/MJE1660, MJE1661 NPN





BRBUMA 20 Characteristic		GE TRANSISTO	Symbol	Min O	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	M.	JE 1290, MJE 1660 JE 1291, MJE 1661	VCEO(sus)	40 60	useful for gh fy. —	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)		e – 2.5 mAdc		nitter Sustail s) = 350 Vd	Collector-El	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 40 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 60 Vdc, V <sub>BE</sub> = 0)		JE1290, MJE1660 JE1291, MJE1661	ICES	- msa g1 (Min) (0 1c) g1 (Min) - 8 - chwid	0.7 0.7	mAdc
Collector Cutoff Current $(V_{CB} = 40 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 60 \text{ Vdc}, I_E = 0)$		JE 1290, MJE 1660 JE 1291, MJE 1661		iHa (Typ) ∰ —	0.7 0.7	mAdc
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>E</sub> = 0)			IEBO	-	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc)			hFE	20	100 A	JMLXAI
(I <sub>C</sub> = 15 Adc, V <sub>CE</sub> = 4.0 Vdc)	tipU	uuls\/	Symbo	10	Roting	
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 1.5 Adc)			VCE(sat)		1.8	Vdc
Base-Emitter on Voltage (1) $(I_C = 15 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc})$	abV.	0.8 en	VBE(on)	zudunil	2.5	Vdc
DYNAMIC CHARACTERISTICS	DBA Add	85.0	gl	- chambi	2007	late Curve
Current-Gain-Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)	Wates	30	d <sup>H</sup> fT	3.0	er Dissipution ibove 25°C	MHz
Small-Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)		001- 61-20	h <sub>fe</sub>	25	ature Range	Temper





The Safe Operating Area Curves indicate  $I_C = V_C E$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_J$ , power-temperature derating must be observed for both steady state and pulse power conditions.

#### NPN SILICON HIGH-VOLTAGE TRANSISTOR

 $_{\rm obv}$  ... useful for general-purpose, high voltage applications requiring high fT.

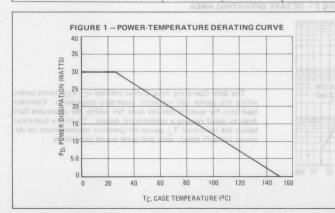
- Collector-Emitter Sustaining Voltage —
   VCEO(sus) = 350 Vdc (Min) @ IC = 2.5 mAdc
- DC Current Gain hFE = 40 (Min) @ IC = 100 mAdc — MJE2361T
  - Current-Gain—Bandwidth Product —
     fT = 10 MHz (Typ) @ IC = 50 mAdc

#### MAXIMIM BATINGS

Symbol	Value	Unit
VCEO	350	Vdc
VCB	375	Vdc
VEB	6.0	Vdc
IC	0.5	Adc
IB	0.25	Adc
PD	30 0.24	Watts W/ <sup>O</sup> C
T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150	°C
	VCEO VCB VEB IC IB	VCEO 350 VCB 375 VEB 6.0 IC 0.5 IB 0.25 PD 30 0.24

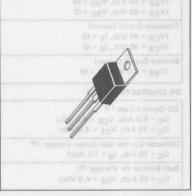
#### THERMAL CHARACTERISTICS

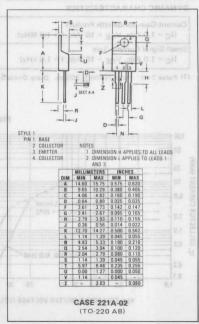
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ JC	4.167	°C/W



## 0.5 AMPERE POWER TRANSISTORS NPN SILICON

350 VOLTS 30 WATTS



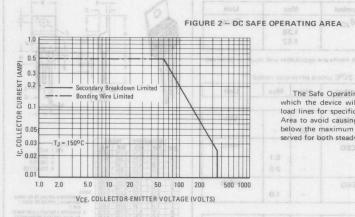


MOTOROLA

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted) Symbol Max Characteristic Min Тур Unit OFF CHARACTERISTICS Collector-Emitter Sustaining Voltage(1) 350 Vdc VCEO(sus) (IC = 2.5 mAdc, IB = 0) Collector Cutoff Current 0.25 mAdc CEO (VCE = 250 Vdc, IB = 0) Collector Cutoff Current 0.5 mAdc CEX (VCE = 375 Vdc, VEB(off) = 1.5 Vdc) Collector Cutoff Current 0.1 mAdc 1CBO (V<sub>CB</sub> = 375 Vdc, I<sub>E</sub> = 0) Emitter Cutoff Current 0.1 mAdc IEBO $(V_{BE} = 5.0 \text{ Vdc}, I_{C} = 0)$ ON CHARACTERISTICS (1) DC Current Gain hFE 25 MJE2360T (IC = 50 mAdc, VCE = 10 Vdc) 200 MJE2361T 50 250 MJE2360T (IC = 100 mAdc, VCE = 10 Vdc) 15 MJE2361T 40 Collector-Emitter Saturation Voltage VCE (sat) 1.5 Vdc (ic = 100 mAdc, IB = 10 mAdc) Base-Emitter On Voltage VBE(on) 1.0 Vdc (I<sub>C</sub> = 100 mAdc, V<sub>CE</sub> = 10 Vdc) DYNAMIC CHARACTERISTICS Current-Gain Bandwidth Product a.fT MHz (IC = 50 mAdc, VCE = 10 Vdc, f = 1.0 MHz) Output Capacitance pF Cob 20



(V<sub>CB</sub> = 100 Vdc, I<sub>E</sub> = 0, f = 100 kHz)



The Safe Operating Area Curves indicate  $I_C-V_{CE}$  limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_J$ , power-temperature derating must be observed for both steady state and pulse power conditions.



#### COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTORS**

... for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain hFE = 25-100 @ IC = 3.0 A
- Choice of Packages MJE2801, 2901 TO-225AB (TO-127) MJE2801T, 2901T - TO-220AB

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Base Voltage	VCB	60	Vdc
Emitter-Base Voltage	VEB	4.0	Toak Vdc
Collector Current	IC	10	Adc
Base Current	1 <sub>B</sub>	5.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C MJE2801, 2901 MJE2801T, 2901T	PD†	90 75	Watts
Derate above 25°C MJE2801, 2901 MJE2801T, 2901T		0.72	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case MJE2801, 2901 MJE2801T, 2901T	0 <sub>JC</sub> ARRA	1.39 1.67	AAR OCW

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

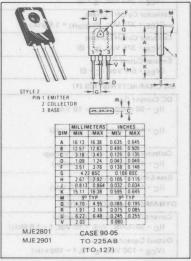
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	sylce will not a	ich the di	dw	
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)				Vdc
Collector-Cutoff Current	<sup>1</sup> CBO			mAdc
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)		-	0.1	
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0, T <sub>C</sub> = 150°C)		-	2.0	
Emitter Cutoff Current	IEBO			mAdc
(VBE = 4.0 Vdc, IC = 0)		-	1.0	

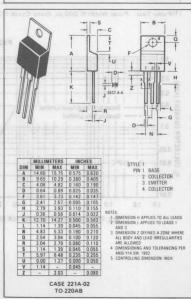
DC Current Gain (IC = 3.0 Adc, VCE = 2.0 Vdc)	hFE	25	100	
Base-Emitter Voltage (IC = 3.0 Adc, VCE = 2.0 Vdc)	VBE	_	1.4	Vdc

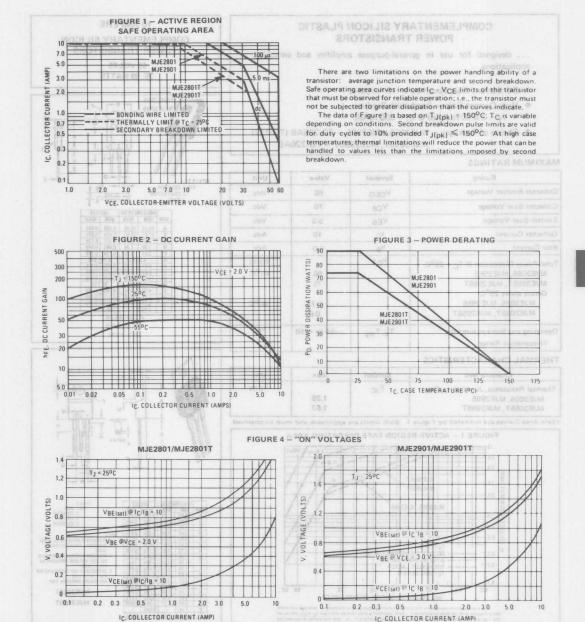
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

#### 10 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60 VOLTS 75, 90 WATTS









## COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

... designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current Gain Bandwidth Product FT = 2.0 MHz (Min) @ IC = 500 mAdc
- Choice of Packages MJE3055, MJE2955 TO-225AB (TO-127)
   MJE3055T, MJE2955T TO-220AB

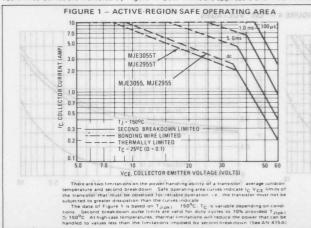
#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Base Voltage	VCB	70	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current	¹c.	10	Adc
Base Current	I <sub>B</sub>	6.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C MJE3055, MJE2955	PD†	90	Watts W/°C
MJE3055T, MJE2955T Derate above 25°C MJE3055, MJE2955 MJE3055T, MJE2955T	Y10853LM	75 0.72 0.6	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C

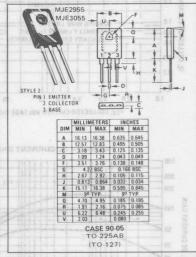
#### THERMAL CHARACTERISTICS

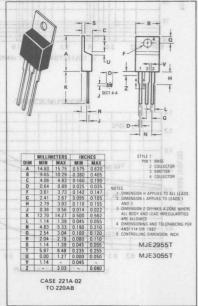
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case MJE3055, MJE2955 MJE3055T, MJE2955T	0 <sub>JC</sub>	1.39 1.67	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.



10 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS
60 VOLTS
75, 90 WATTS





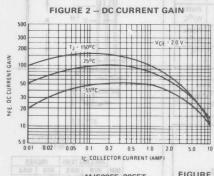


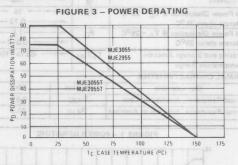
## MJE3310 MJE3311 MJE3312 PNP

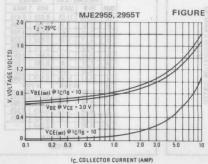
#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

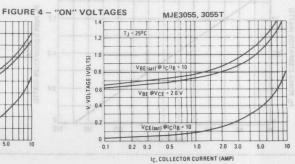
Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS		Veni	A THAT SAME AND	18700 June 10		W. W. C. A. B. S.
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)		280	VCEO(sus)	60	ANNULA	Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0)	· ·	301021902 (2	CEO	eingme esoc	700	μAdc
Collector Cutoff Current (VCE = 70 Vdc, VEB(off) = 1.5 Vdc) (VCE = 70 Vdc, VEB(off) = 1.5 Vdc, TC = 150°C)			CEX	j = 1.Q.Ade ng Voltage — f	9 (1.0)	nFE = 2001
Collector Cutoff Current (VCB = 70 Vdc, IE = 0) (VCB = 70 Vdc, IE = 0, TC = 150°C)			СВО	Min) - MJE33 Min) - MJE33 Min) - MJE33	= 40 Vac (	
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)			IEBO			mAdc
ON CHARACTERISTICS		Tuqti	ase-Emitter Or	vich Built-In Ba	notion to	Monolithic Co
DC Current Gain (1) (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)			hFE Solder for Hill	5.0	100	Resistor  Thermopad III Reliability
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 0.4 Adc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 3.3 Adc)		Terrence	VCE(sat)	-	1.1	Vdc MUM RATINGS
Base-Emitter On Voltage (1)	Unit	2085300	V <sub>BE(on)</sub>	Symbol (8)		Vdc
(I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc)			08 08	V <sub>GEO</sub> V I	1.8	or-Emitter Vollage
DYNAMIC CHARACTERISTICS	Voc	03	08 36	1		egittleV sas8-vo
Current-Gain-Bandwidth Product (IC = 500 mAdc, VCE = 10 Vdc, f = 500 kHz)	ohA		0.0 fT	2.0	14000	MHz

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.











#### PLASTIC DARLINGTON COMPLEMENTARY SILICON ANNULAR POWER TRANSISTORS

. . designed for general-purpose amplifier and high-speed switching applications.

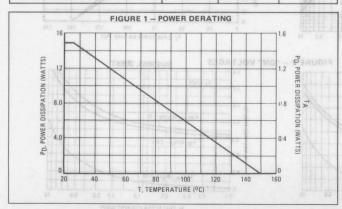
- High DC Current Gain
  - hFE = 2000 (Typ) @ IC = 1.0 Adc
- Collector-Emitter Sustaining Voltage @ 10 mAdc VCEO(sus) = 40 Vdc (Min) - MJE3310/MJE3300
  - = 60 Vdc (Min) MJE3311/MJE3301
  - = 80 Vdc (Min) MJE3312/MJE3302
- Reverse Voltage Protection Diode
- Pinout Compatible with TO-220 Package
- Monolithic Construction with Built-In Base-Emitter Output
- Thermopad II Construction With Hard Solder for High Reliability

#### MAXIMUM RATINGS

Rating	Symbol			MJE3312 MJE3302	Unit
Collector-Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage	VCB	40	60	80	Vdc
Emitter-Base Voltage	VEB	-	5.0	-	Vdc
Collector Current - Continuous Peak	o'c	1	- 4.0 - - 6.0 -		Adc
Base Current	IB	-	—100 —	-	mAdc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	- PD	-	— 15 — — 0.12—		Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1	1.5 0.012 -		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-	-65 to +15	0	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	8.33	°CM
Thermal Resistance, Junction to Ambient	$R_{\theta}JA$	83.3	°CM

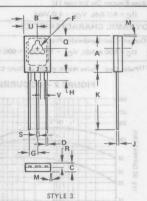


#### DARLINGTON 4-AMPERE

#### COMPLEMENTARY SILICON POWER TRANSISTORS

40, 60, 80 VOLTS 15 WATTS





PIN 1. BASE 2. COLLECTOR

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	O TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
V	1.02	-	0.040	-
		ASE 77	.04	3.
	10	TO-12	-	
		10-12	U	

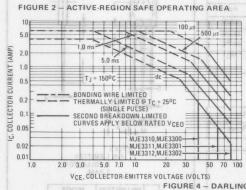
## MJE3300, MJE3301, MJE3302 NPN MJE3310, MJE3311, MJE3312 PNP

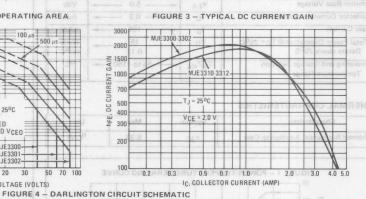


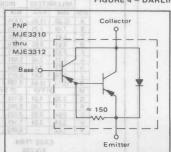
ELECTRICAL	CHARACTERISTICS	(Tc = 25°C unless otherwise noted.)

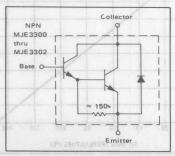
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
MJES	3310,MJE3300 3311,MJE3301 3312,MJE3302	VCEO(sus)	40 60 80	_	Vdc
(VCE = 30 Vdc, IB = 0) MJE3	3310,MJE3300 3311,MJE3301 3312,MJE3302	OBO!	LTAGE POV	100 100	DPN SILICI
Collector Cutoff Current (VCB = Rated VCEO(sus), IE = 0) (VCB = Rated VCEO(sus), IE = 0, TC = 10		СВО	operat <u>e</u> d equip	1.020 101	μAdc
Emitter Cutoff Current TAW (IV) (VBE = 5.0 Vdc, IC = 0)		IEBO	-	0.1 Irrent Gain -	μAdc High DC O
ON CHARACTERISTICS			obAm 0	0-100 @ IC = 3I	hpe = 4
DC Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)		hFE	1000 750	n-Bandwidth Milz (Min) (8 ig	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> = 6.0 mAdc)		VCE(sat)	= 1.0 MHz	1.5 (xaM) 3q (	Vdc
Base-Emitter Saturation Voltage (IC = 1.5 Adc, IB = 6.0 mAdc)		V <sub>BE</sub> (sat)	-	2.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.5 Adc, V <sub>CE</sub> = 2.0 Vdc)	1	VBE(on)	-	2.5	Vdc
Output Diode Voltage Drop (IEC = 2.0 Adc)		VEC	-	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	obV Vide	fT 088	20	- 10	MHz

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.











#### NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

. . . designed for use in line-operated equipment requiring high f<sub>T</sub>.

- High DC Current Gain hFE = 40-160 @ I<sub>C</sub> = 20 mAdc
- Current-Gain—Bandwidth Product fT = 15 MHz (Min) @ IC = 10 mAdc
- Low Output Capacitance –
   Cob = 10 pF (Max) @ f = 1.0 MHz

#### 0.3 AMPERE OF SOM

POWER TRANSISTORS NPN SILICON

250-350 VOLTS 15 WATTS 15 WATTS

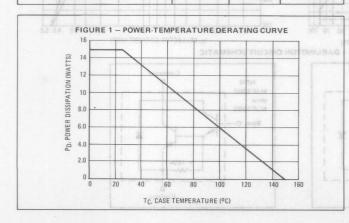


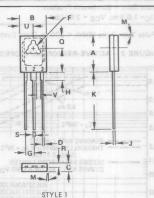
#### **MAXIMUM RATINGS**

Rating	Symbol	MJE3439	MJE3440	Unit
Collector-Emitter Voltage	VCEO	350	250	Vdc
Collector-Base Voltage	VCB	450	350	Vdc
Emitter-Base Voltage	VEB	- 5	.0	Vdc
Collector Current - Continuous	TIC-E	- 0	.3	Adc
Base Current	I B	1	50	mAdo
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	-	12	Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to	p +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θЈС	8.33	°C/W





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
В	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
Н	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.655
M	3	0 TYP	30 T	YP
0	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155
٧	1.02	-	0.040	-

TO-126



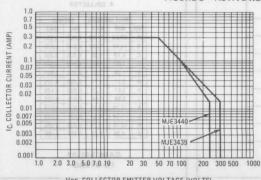
#### ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	SROT	R TRANSIST	HIGH POWE	H-VOLTAGE -	HIGH
Collector-Emitter Sustaining Voltage $(I_C = 5.0 \text{ mAdc}, I_B = 0)$ $(I_C = 50 \text{ mAdc}, I_B = 0)$	MJE3439 MJE3440	VCEO(sus)	350 250	ned for use in he age switching re Selector Eminer	
Collector Cutoff Current (V <sub>CE</sub> = 300 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 200 Vdc, I <sub>B</sub> = 0)	MJE3439 MJE3440	ICEO		20 50	μAdc
Collector Cutoff Current (V <sub>CE</sub> = 450 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc) (V <sub>CE</sub> = 300 Vdc, V <sub>EB</sub> (off) = 1.5 Vdc)	MJE3439 MJE3440	CEX		500 500	μAdc
Collector Cutoff Current ( $V_{CB} = 350 \text{ Vdc}$ , $I_E = 0$ ) ( $V_{CB} = 250 \text{ Vdc}$ , $I_E = 0$ )	MJE3439 MJE3440		Saturat <del>o</del> n Voite		μAdc B wo.l to
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	-	20	μAdc

#### ON CHARACTERISTICS DC Current Gain hFE (IC = 2.0 mAdc, VCE = 10 Vdc) 30 (IC = 20 mAdc, VCE = 10 Vdc) 200 50 Collector-Emitter Saturation Voltage 0.5 Vdc VCE (sat) (I<sub>C</sub> = 50 mAdc, I<sub>B</sub> = 4.0 mAdc) Base-Emitter Saturation Voltage VBE (sat) 1.3 Vdc (IC = 50 mAdc, IB = 4.0 mAdc) Base-Emitter On Voltage VBE(on) 0.8 Vdc (I<sub>C</sub> = 50 mAdc, V<sub>CE</sub> = 10 Vdc)

#### DYNAMIC CHARACTERISTICS Current-Gain-Bandwidth Product fT 15 MHz (I<sub>C</sub> = 10 mAdc, V<sub>CE</sub> = 10 Vdc, f = 5.0 MHz) Cob 10 Output Capacitance pF (V<sub>CB</sub> = 10 Vdc, I<sub>E</sub> = 0, f = 1.0 MHz) Small-Signal Current Gain 25 hfe $(I_C = 5.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz})$

#### FIGURE 2 - ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I<sub>C</sub>-V<sub>CE</sub> limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T<sub>J</sub>, power-temperature derating must be observed for both steady state and pulse power conditions.

VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

NPN PNP **MIF4343** MIF4353





#### HIGH-VOLTAGE - HIGH POWER TRANSISTORS designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

High Collector-Emitter Sustaining Voltage —

	NPN	PNP
VCEO(sus) = 100 V	dc - MJE4340	MJE4350
= 120 V	dc - MJE4341	MJE4351
= 140 V	dc - MJE4342	MJE4352
-1601/	A BAIEASAS	BA IEASES

- High DC Current Gain @ Ic = 8.0 Adc hFE = 35 (Typ)
- Low Collector-Emitter Saturation Voltage VCE(sat) = 2.0 Vdc (Max) @ IC = 8.0 Adc

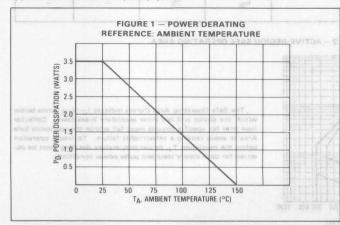
#### MAXIMUM RATINGS

Rating	Symbol		MJE4341 MJE4351	MJE4342 MJE4352	MJE4343 MJE4353	Unit
Collector-Emitter Voltage	VCEO	100	120	140	160	Vdc
Collector-Base Voltage	VCB	100	120	140	160	Vdc
Emitter-Base Voltage	VEB	-	7	.0	-	Vdc
Collector Current — Continuous Peak (1)	lc	4		6	-	Adc
Base Current — Continous	I <sub>B</sub>	4	5	.0 —	-	Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C	PD	4	1	25 no)38 <sup>V</sup>	-	Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to	+150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.0	°C/W	

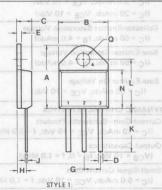
(1) Pulse Test: Pulse Width ≤ 5.0 µs, Duty Cycle ≥10%.



#### 16 AMPERE ARAHO 190 POWER TRANSISTORS COMPLEMENTARY SILICON

100-160 VOLTS TO TOTOGICO





1 RASE 2. COLLECTOR 3 EMITTER

1	MILLIMETERS		INCHES		
DIM	MIN	MAX	MIN	MAX	
A	20.32	21.08	0.800	0.830	
В	15,49	15.90	0.610	0.626	
C	4.19	5.08	0.165	0.200	
D	1.02	1.65	0.040	0.065	
E	1.35	1.65	0.053	0.065	
G	5.21	5.72	0.205	0.225	
Н	2.41	3.20	0.095	0.126	
J	0.38	0.64	0.015	0.025	
K	12.70	15.49	0.500	0.610	
L	15.88	16.51	0.625	0.650	
N	12.19	12.70	0.480	0.500	
0	4.04	4.22	0.159	0.166	

CASE 340-01 TO-218AC

#### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Charact	eristic BOITSIRSTOARA	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	a periora	and and	ET BRO-MEU	FIGURE 4 - T	
Collector-Emitter Sustaining Volta	ge (1)	VCEO(sus)			Vdc
(I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	MJE4340, MJE4350	39-25-17	100		
	MJE4341, MJE4351	21-8/3	120	11+11-1	
	MJE4342, MJE4352	201-10	140		0.5
	MJE4343, MJE4353	V 65 - 30	160		
Collector-Emitter Cutoff Current	111111111111111111111111111111111111111	ICEO			μAdc
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	MJE4340, MJE4350		/-	750	
(VCE = 60 Vdc, IB = 0)	MJE4341, MJE4351			750	-
(V <sub>CE</sub> = 70 Vdc, I <sub>B</sub> = 0)	MJE4342, MJE4352			750	
(V <sub>CE</sub> = 80 Vdc, I <sub>B</sub> = 0)	MJE4343, MJE4353	DX.LL	- 1	750	Linx
Collector-Emitter Cutoff Current	A 07 - 33A 0 35A	ICEX			mAdc
(VCE = Rated VCB, VEB(off) = 1.5	Vdc)		P P	1.0	100
(VCE = Rated VCB, VEB(off) = 1.5	Vdc, T <sub>C</sub> = 150°C)		-	5.0	
Collector-Base Cutoff Current		Ісво	1-1-1-	750	μAdc
(V <sub>CB</sub> = Rated V <sub>CB</sub> , I <sub>E</sub> = 0)	11 TO 212 C.O S.N	83 7.0 18 80		0.5 VB 0.0	10 70
Emitter-Base Cutoff Current	100 3	IEBO	_	1.0	mAdc
(VBF = 7.0 Vdc, IC = 0)					

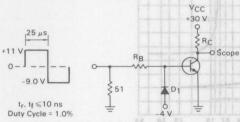
DC Current Gain (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 4.0 Vdc)	hFE (MS	4) 231A 38 04 5 15 8.0	35 (Typ) 15 (Typ)	FIG. = 1001
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 8.0 Adc, I <sub>B</sub> = 800 mA) (I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 2.0 Adc)	VCE(sat)		2.0 3.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 16 Adc, I <sub>B</sub> = 2.0 Adc)	V <sub>BE(sat)</sub>	T-We	3.9	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 16 Adc, V <sub>CE</sub> = 4.0 Vdc)	V <sub>BE(on)</sub>	47	3.9	Vdc
DYNAMIC CHARACTERISTICS	1-6-9514		= 30V 4	60
Coursest Cain Bondwidth Bradust (2)	1/4	10		A411

Current-Gain—Bandwidth Product (2)	fT	1.0		MHz
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 20 Vdc, f <sub>test</sub> = 0.5 MHz)		1 3008- 1		
Output Capacitance	Cob		800	pF or
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	02 01	0.6 5.5	0.1 8.8	

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≥ 2.0%.

(2) fT = |hfe| • ftest

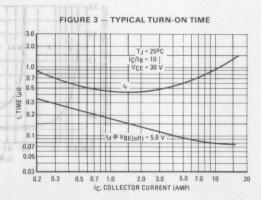
#### FIGURE 2 — SWITCHING TIMES TEST CIRCUIT



RB and RC varied to obtain desired current levels

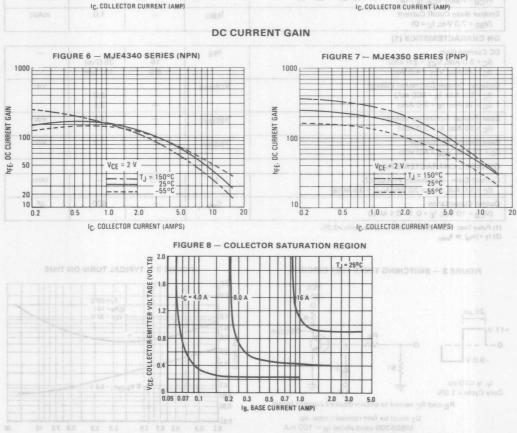
D<sub>1</sub> must be fast recovery type, eg: MBD5300 used above I<sub>B</sub>  $\approx$  100 mA MSD6100 used below I<sub>B</sub>  $\approx$  100 mA

Note: Reverse polarities to test PNP devices.



ELECTRICAL CHARACTERISTICS ITC - 25°C unless one





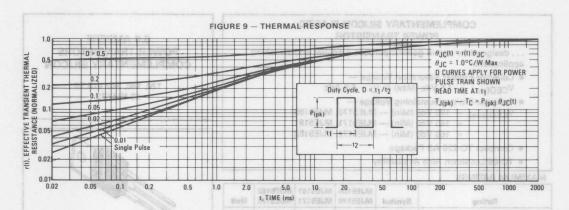
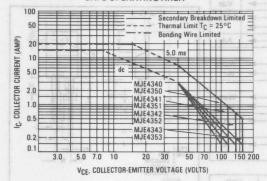


FIGURE 10 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA

MOTOROLA



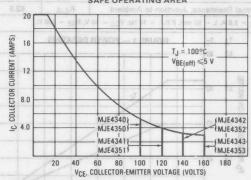
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 10 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on Figure 9.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 11 gives RBSOA characteristics.

FIGURE 11 — MAXIMUM REVERSE BIAS SAFE OPERATING AREA



**MJE5180** MJE5181

MJE4340 thru MJE4343NPN, MJE4350 thru MJE431 MJE5170 **MJE5171** 

**MJE5172 MJE5182** 



### COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTOR**

- ... designed for use in general purpose amplifier and switching applications.
- Collector-Emitter Saturation Voltage VCEO(sat) = 1.5 Vdc (Max) @ IC = 6.0 Adc
- Collector-Emitter Sustaining Voltage —
- VCEO(sus) = 120 Vdc (Min) MJE5170, MJE5180 = 140 Vdc (Min) — MJE5171, MJE5181
  - = 160 Vdc (Min) MJE5172, MJE5182
- Compact TO-220 AB Package
- TO-66 Leadform Also Availability

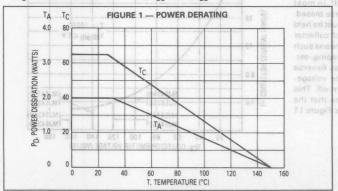
#### MAYIMI IM DATINGS

Rating	Symbol	MJE5180 MJE5170	MJE5181 MJE5171	MJE5182 MJE5172	Unit
Collector-Emitter Voltage	VCEO	120	140	160	Vdc
Collector-Base Voltage	VCB	120	140	160	Vdc
Emitter-Base Voltage	VEB	4	— 5.0 —	-	Vdc
Collector Current — Continuous Peak	age junct	mi awi ma	- 6 - - 10 -		Adc
Base Current	IB	vn. Sete	— 2.0 —	-	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD 1	-	— 65 — — 0.52 —	<b></b>	Watts W/°C
Total Power Dissipation  @ T <sub>A</sub> = 25°C  Derate above 25°C	tub not bit		— 2.0 — —0.016 —	=	Watts W/°C
Unclamped Inductive and I lamp Load Energy (1) Of any 3 no.					mJ
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to +15	50	°C

### THERMAL CHARACTERISTICS

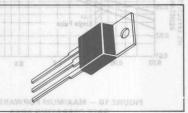
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>Ø</sub> JC	1.92	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W

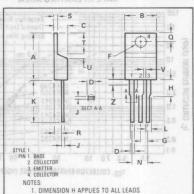
(1) I\_C = 2.8 A, L = 50 mH, P.R.F. = 10 Hz, V\_{CC} = 10 V, R\_{BE} = 100  $\Omega$ .



### **6.0 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON**

120, 140, 160 VOLTS 65 WATTS



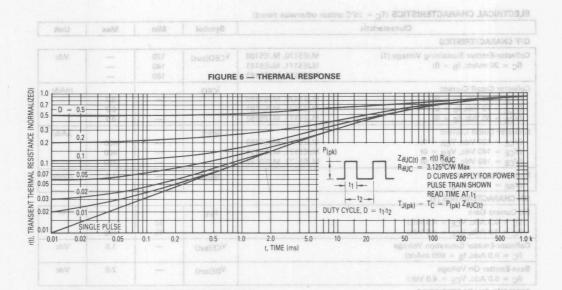


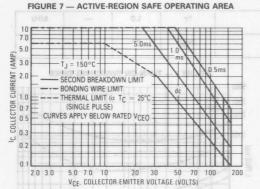
- 2. DIMENSION L APPLIES TO LEADS 1
- AND 3
- 3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES
- 4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- 5. CONTROLLING DIMENSION: INCH.



(TO-220AB)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		,		
Collector-Emitter Sustaining Voltage (1) MJE5170, MJE5180 (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0) MJE5171, MJE5181	VCEO(sus)	120 140	Ξ	Vdc
MJE5172, MJE5182	BRUDR	160		
Collector Cutoff Current	ICEO			mAdc
(V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0) MJE5170, MJE5180		- 11	0.7	the state of
(V <sub>CE</sub> = 70 Vdc, I <sub>B</sub> = 0) MJE5171, MJE5181			0.7	d0 = 0-1
(V <sub>CE</sub> = 80 Vdc, I <sub>B</sub> = 0) MJE5172, MJE5182			0.7	
Collector Cutoff Current	ICES	11111		μAdc
(V <sub>CE</sub> = 120 Vdc, V <sub>EB</sub> = 0) MJE5170, MJE5180		-	400	2
(VCE = 140 Vdc, VEB = 0) MJE5171, MJE5181		- 11	400	10
(V <sub>CE</sub> = 160 Vdc, V <sub>EB</sub> = 0) MJE5172, MJE5182		_	400	
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	IEBO		1.0	mAdc
ON CHARACTERISTICS (1)			-LIT-	10.0
DC Current Gain	her			000000000000000000000000000000000000000
(I <sub>C</sub> = 0.3 Adc, V <sub>CE</sub> = 4.0 Vdc)	hFE	30	HIJS	1
$(I_C = 0.3 \text{ Adc}, V_{CE} = 4.0 \text{ Vdc})$		15	100	
0.1 0.0 0.0 0.0 0.0	N 50	50 10	10.0	10.0
Collector-Emitter Saturation Voltage (IC = 6.0 Adc, IB = 600 mAdc)	VCE(sat)		1.5	Vdc
Base-Emitter On Voltage (IC = 6.0 Adc, VCE = 4.0 Vdc)	VBE(on)	Ī	2.0	Vdc
DYNAMIC CHARACTERISTICS	OPERATING	EGION SAP		FIGURE 7
Current Gain — Bandwidth Product (2) (IC = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1.0 MHz)	fT	1.0	_	MHz
Small-Signal Current Gain Spanners and Spann	h <sub>fe</sub>	20		
(IC = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	i. iei	20	PER TENT	
25 μς	FIGURE 3 — 1	TURN-ON SV	WITCHING TI	MES
(2) f <sub>T</sub> =  hfe  • frest  *FIGURE 2 — SWITCHING TIME TEST CIRCUIT	IPN —			
*FIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC + 30 V 3000 $\frac{1}{11}$ VCC + 30 V $\frac{25 \mu\text{s}}{11}$	IPN		WITCHING TI	
(2) f <sub>T</sub> =  hfe  • frest  *FIGURE 2 — SWITCHING TIME TEST CIRCUIT	IPN NP			
PFIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC + 30 V 3000 PR RC 2000 PR	IPN			
PROUNT CYCLE = 1.0%  RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS  D1 MUST BE FAST RECOVERY TYPE, eg: $1000 \text{ Proposed for a Recovery type, eg:}$	IPN NP	t <sub>d</sub> (c	VBE(off) = 5.0	
*FIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC + 30 V 3000 $\frac{1}{11}$ VCC + 30 V 2000 $\frac{25  \mu s}{11}$ VCC + 30 VCC + 30 V 2000 $\frac{25  \mu s}{11}$ VCC + 30 V 2000 $\frac{25  \mu s}{11$	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2.0 3.0 3.0 RRENT (AMPS)	V
*FIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC + 30 V 3000 $\frac{25  \mu \text{s}}{110  \text{V}}$ $\frac{25  \mu \text{s}}{100  \text{C}}$ $\frac{25  \mu \text{s}}{1$	PN NP	t <sub>d</sub> «	VBE(off) = 5.0 2.0 3.0 3.0 RRENT (AMPS)	V
(2) f <sub>T</sub> =  hfe  • frest     FIGURE 2 — SWITCHING TIME TEST CIRCUIT   V <sub>CC</sub>   +30 V     25 μs   2000     11 V   -25 μs   2000     12 μs   25 μs   2000     13 μs   25 μs   2000     14 μs   25 μs   2000     15 μs   25 μs   2000     16 μs   25 μs   2000     17 μs   25 μs   2000     18 μs   25 μs   2000     19 μs   25 μs   2000     10 μs   25 μs   25 μs   25 μs   25 μs   25 μs     10 μs   25	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2.0 3.0 3.0 RRENT (AMPS)	V
(2) f <sub>T</sub> =  hfe  • frest     FIGURE 2 — SWITCHING TIME TEST CIRCUIT   V <sub>CC</sub>   +30 V     11 V	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2.0 3.0 3.0 RRENT (AMPS)	V
(2) f <sub>T</sub> =  hfe  • frest     FIGURE 2 — SWITCHING TIME TEST CIRCUIT   V <sub>CC</sub>   +30 V     25 μs   2000     11 V   -25 μs   2000     12 μs   25 μs   2000     13 μs   25 μs   2000     14 μs   25 μs   2000     15 μs   25 μs   2000     16 μs   25 μs   2000     17 μs   25 μs   2000     18 μs   25 μs   2000     19 μs   25 μs   2000     10 μs   25 μs   25 μs   25 μs   25 μs   25 μs     10 μs   25	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2.0 3.0 3.0 RRENT (AMPS)	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest  PFIGURE 2 — SWITCHING TIME TEST CIRCUIT	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   VCC   +30 V   3000   10 V	PN NP	1 <sub>d</sub> (c. 1 <sub>d</sub>	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   VCC   +30 V   3000   10 V	PN NP	t <sub>d</sub> (c. 1.0 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.7 1.0 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   VCC   +30 V   3000   10 V	PN NP	1 <sub>d</sub> (c. 1 <sub>d</sub>	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   VCC   +30 V   3000   10 V	PN NP	1 <sub>d</sub> (c. 1 <sub>d</sub>	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
(2) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   VCC   +30 V   3000   10 V	PN NP	0.5 0.7 1.0 Cib	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
*FIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC +30 V 3000 $\frac{1}{1000}$ $\frac{25  \mu s}{1000}$ $\frac{25  \mu s}{10000}$ $\frac{25  \mu s}{10000}$ $\frac{25  \mu s}{10000}$ $\frac{25  \mu s}{100000}$ $\frac{25  \mu s}{100000}$ $\frac{25  \mu s}{100000}$ $\frac{25  \mu s}{100000}$ $\frac{25  \mu s}{1000000}$ $\frac{25  \mu s}{100000000}$ $\frac{25  \mu s}{1000000000000000000000000000000000000$	PN NP	1 <sub>d</sub> (c. 1 <sub>d</sub>	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
25 μs   5000   70   70   70   70   70   70	PN NP	0.5 0.7 1.0 Cib	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
12) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   V <sub>CC</sub>   +30 V   3000   1000	PN NP	0.5 0.7 1.0 Cib	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
*FIGURE 2 — SWITCHING TIME TEST CIRCUIT VCC +30 V 3000 PC 11 V CC +30 V 2000 PC 11 V CC +30 V 2000 PC 11 V CYCLE = 1.0% PC 10	PN NP	0.5 0.7 1.0 Cib	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0
12) f <sub>T</sub> =  hfe  • frest   • FIGURE 2 — SWITCHING TIME TEST CIRCUIT   V <sub>CC</sub>   +30 V   3000   1000	PN NP	L <sub>d</sub> (c.) 0.5 0.7 1.0 COLLECTOR CUE Cib Cob	VBE(off) = 5.0 2:0 3.0 RRENT (AMPS) ACITANCE	5.0 7.0





There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

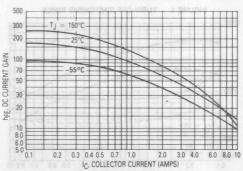
The data of Figure 7 is based on  $T_{J(pk)}=150^{\circ}\text{C};~T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}\text{C}.~T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 8 — DC CURRENT GAIN 500 400 300 = 150°C 200 - 55°C DC CURRENT GAIN 100 70 50 30 VCE 20 hE, 10 3.0 4.0 0.1 0.2 0.03 0.5 6.0 8.0 10 IC, COLLECTOR CURRENT (AMPS)

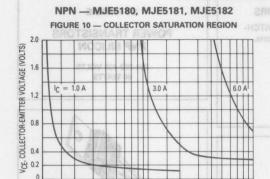
NPN — MJE5180, MJE5181, MJE5182

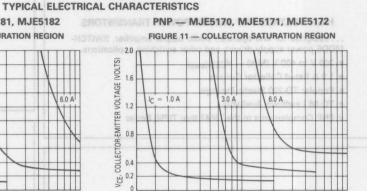
## PNP — MJE5170, MJE5171, MJE5172 FIGURE 9 — DC CURRENT GAIN

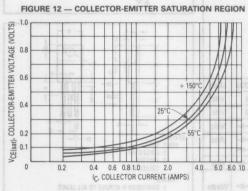




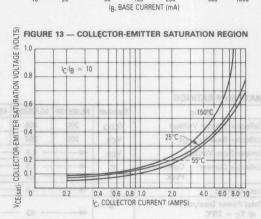


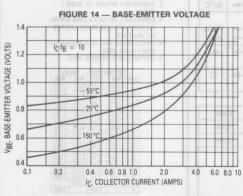


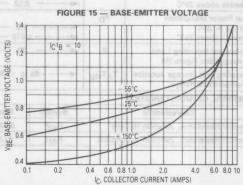




IR, BASE CURRENT (mA)



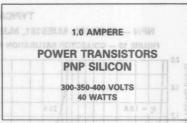


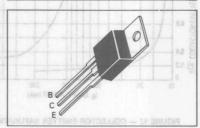


### HIGH VOLTAGE PNP SILICON POWER TRANSISTORS

... designed for line operated audio output amplifier, SWITCH-MODE power supply drivers and other switching applications.

- 300 V to 400 V (Min) VCEO(sus)
- 1.0 A Rated Collector Current
- Popular TO-220 Plastic Package
- TO-66 Leadform Available
- PNP Complements to the TIP47 thru TIP50 Series







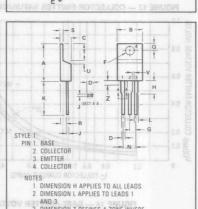


### **MAXIMUM RATINGS**

Rating	Symbol	MJE5730	MJE5731	MJE5732	Unit
Collector-Emitter Voltage	VCEO	300	350	400	Vdc
Collector-Base Voltage	VCB	300	350	400	Vdc
Emitter-Base Voltage	VEB	4	— 5.0 —	-	Vdc
Collector Current — Continuous Peak	lc	4	— 1.0 — — 3.0 —	-	Adc
Base Current	IB A	4 50	1.0		Adc
Total Power Dissipation Total	PD P	4	— 40 — — 0.32 —	<u></u>	Watts W/°C
Total Power Dissipation  @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	INUUN	2.0 0.016	-	Watts W/°C
Unclamped Inducting Load Energy (See Figure 10)	E	<b>*</b>	_ 20 _	-	mJ
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	4	-65 to +15	50	°C

### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>O</sub> JC	3.125	°C/W
Thermal Resistance, Junction to Ambient	R <sub>0</sub> JA	62.5	°C/W

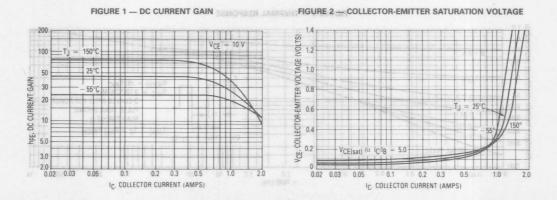


- DIMENSION L APPLIES TO LEADS 1
   ANO 3
   DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES
- ARE ALLOWED.
  4. DIMENSIONING AND TOLERANCING PER
- ANSI Y14.5M, 1982.
  5. CONTROLLING DIMENSION: INCH.

	MILLIMETERS		INC	HES
MIC	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	361	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
\$	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1:14	107-	0.045	-
Z	-	2.03	-	0.080

TO-220AB

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS	70				
Collector-Emitter Sustaining Voltage (1) (IC = 30 mAdc, IB = 0)	MJE5730 MJE5731 MJE5732	VCEO(sus)	300 350 400	-8 2 = u(0) v)	Vdc 0.1
Collector Cutoff Current (V <sub>CE</sub> = 200 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 250 Vdc, I <sub>B</sub> = 0) (V <sub>CE</sub> = 300 Vdc, I <sub>B</sub> = 0)	MJE5730 MJE5731 MJE5732	ICEO		1.0 1.0 1.0	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 300 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 350 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 400 Vdc, V <sub>BE</sub> = 0)	MJE5730 MJE5731 MJE5732	ICES		1.0 1.0 1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	0. 9/3	IEBO (8	A CURRENT (AMP	1.0	mAdc
ON CHARAC ERISTICS (1)					_
DC Current Gain (I <sub>C</sub> = 0.3 Adc, $V_{CE}$ = 10 Vdc) (I <sub>C</sub> = 1.0 Adc, $V_{CE}$ = 10 Vdc)		HA S hFE H34	30 10	150	HRUD <del>H</del>
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.2 Adc)	lty of second	VCE(sat)		1.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc)	IC-VCE	VBE(on)	444	1.5	Vdc
DYNAMIC CHARACTERISTICS				3.92	- 01 H H d.C
Current Gain — Bandwidth Product (I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 10 Vdc, f = 2.0 MHz)	eriT -3	to trans	10		MHz
Small-Signal Current Gain (I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	pulse I	h <sub>fe</sub>	25	THERMAL SUST	30.0
(1) Pulse Test: Pulsewidth ≤ 300 μs, Duty Cycle ≤ 2.0%.  Exp. of belibrari and replaced lawood securities and replaced lawood securities.	in Figurions w	MJE5731 MJE5731 MJE5732 MJE5732	201 0.5 11 1 1 1	20 30	1.02 1.01 5.0 10



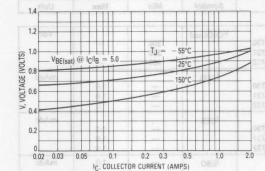


FIGURE 3 - BASE-EMITTER VOLTAGE

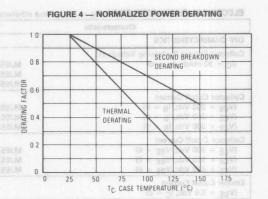
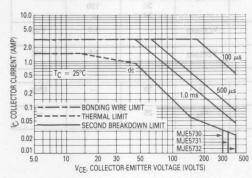


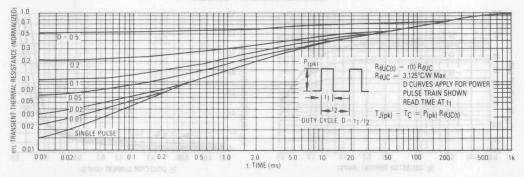
FIGURE 5 — FORWARD BIAS SAFE OPERATING AREA



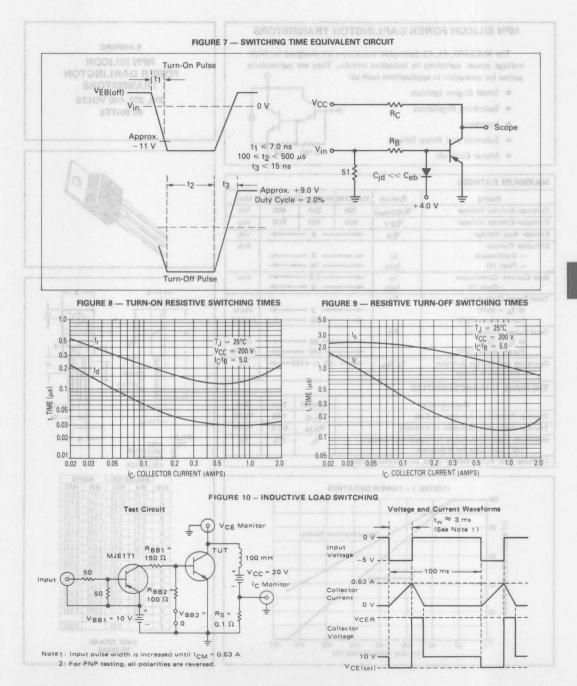
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate Ic-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}=150^{\circ}\text{C};\ T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 150^{\circ}\text{C}.\ T_{J(pk)}$  may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 6 — THERMAL RESPONSE





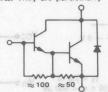




### NPN SILICON POWER DARLINGTON TRANSISTORS

The MJE5740, 41, 42 darlington transistors are designed for high-voltage power switching in inductive circuits. They are particularly suited for operation in applications such as:  $\varphi$ 

- Small Engine Ignition
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls



-65 to +150-

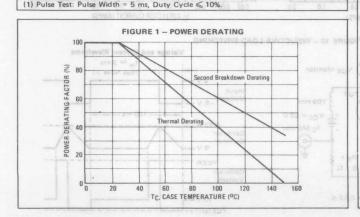
MAXIMUM RATINGS	T down bla		12.00		
Rating	Symbol	MJE5740	MJE5741	MJE5742	Unit
Collector-Emitter Voltage	VCEO(sus)	300	350	400	Vdc
Collector-Emitter Voltage	VCEV	600	700	800	Vdc
Emitter Base Voltage	VEB	4	_ 8 _	-	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub> M	<del>+</del>	8 16	<b>→</b>	Adc
Base Current—Continuous —Peak (1)	I <sub>B</sub>	<b>+</b>	2.5 — 5 —	$\Rightarrow$	Adc
Total Power Dissipation  @ T <sub>A</sub> = 25°C  Derate above 25°C	MART SVPPISS	( - £ 3/10)	2 - 16 -	83M	Watts mW/°C
Total Power Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		80 - 640 -	<b>→</b>	Watts mW/°C

# Temperature Range

Operating and Storage Junction

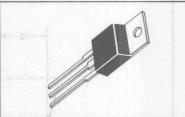
THERMAL CHARACTERISTICS  Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	1.56	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	oc/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

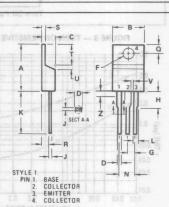
T<sub>J</sub>, T<sub>stg</sub>



8 AMPERE
NPN SILICON

POWER DARLINGTON TRANSISTORS 300, 350, 400 VOLTS 80 WATTS





	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
Ko	12.70	14.27	0.500	0.562
LA	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	04 /	0.045	-
Z	-	2.03	-	0.080

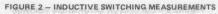
TO-220AB

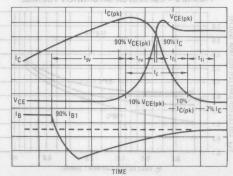
3

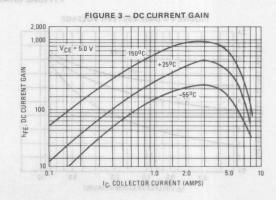
### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Sustaining Voltage MJE5740	VCEO (sus)	300	_	-	Vdc
(I <sub>C</sub> = 50 mA, I <sub>B</sub> = 0) MJE5741	020(303)	350	-	_	
BOWAMAGRARA DIMAN MJE5742	SITIGNOS TES	400	T -	_	
Collector Cutoff Current  (VCEV = Rated Value, VBE (off) = 1.5 Vdc)	INA CEVAD	MERATIN	AS SAFE	a sensval	mAdc
(VCEV = Rated Value, VBE (off) = 1.5 Vdc, TC = 100°C)		-		5	
Emitter Cutoff Current	IEBO	-	-	75	mAdc
(VEB = 8 Vdc, IC = 0)	LANGE CERAL				
SECOND BREAKDOWN					
Second Breakdown Collector Current with base forward biased	Is/b	9 Au 100	See F	igure 6	- 00
Clamped Inductive SOA with Base Reverse Biased	RBSOA	-	See F	igure 7	
ON CHARACTERISTICS (1)	1 1	Al Al	100 300	uny Cycle ≤ 1	0 1
DC Current Gain	hFE -	eva-		80 01 = 17 m	1 5
(1 <sub>C</sub> = 0.5 Adc, V <sub>CF</sub> = 5 Vdc)	F	50	100	_	- 4
(I <sub>C</sub> = 4 Adc, V <sub>CE</sub> = 5 Vdc)	ADDOLES S	200	400	_	
Collector-Emitter Saturation Voltage	VCE(sat)	94.8	1.0		Vdc
(I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.2 Adc)	GO 13 W 35	-		2	TOM
(I <sub>C</sub> = 8 Adc, I <sub>B</sub> = 0.4 Adc)	1	- St. De	rest for our	O tol 3 mulby	oB.
(I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.2 Adc, T <sub>C</sub> = 100°C)		-	-	2.2	
Base-Emitter Saturation Voltage	V <sub>BE</sub> (sat)				Vdc
(IC = 4 Adc, IB = 0.2 Adc)	GAP 101 200	-	-	2.5	00 -
(1a = 9 Ado 1a = 0.4 Ado)	Logue 200	- 1	BBIAL #100 a		7.5
(I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 0.2 Adc, T <sub>C</sub> = 100°C)	100	_37 th (s	muTaf~) n	2.4	33
Diode Forward Voltage (2)	Vf	-		2.5	Vdc
(I <sub>F</sub> = 5 Adc)					
SWITCHING CHARACTERISTICS	SH LOTTED	begme	IO h	6.51	
Typical Resistive Load (Table 1)	11		VK	August 1	8
Delay Time $(V_{CC} = 250 \text{ Vdc}, I_{C(pk)} = 6A)$	td	-	0.04	X1+ 1	μѕ
Rise Time $I_{B1} = I_{B2} = 0.25A$ , $t_p = 25 \mu s$ ,	tr	-	0.5		μs
Storage Time Duty Cycle ≤1%)	ts	-	8.0	-	μs
Fall Time	tf	-	2.0	A.J. A BOY	μs
nductive Load, Clamped (Table 1)	61		Tomsi	SV Y	15 UI
Voltage Storage Time $I_{C(pk)} = 6A, V_{CE}(pk) = 250 \text{ Vdc}$	t <sub>sv</sub>		4.0		μs
Crossover Time 1 181 = 0.06 A, VBE(off) = 5 Vdc)	t <sub>c</sub>		2.0	Will be a second	μs

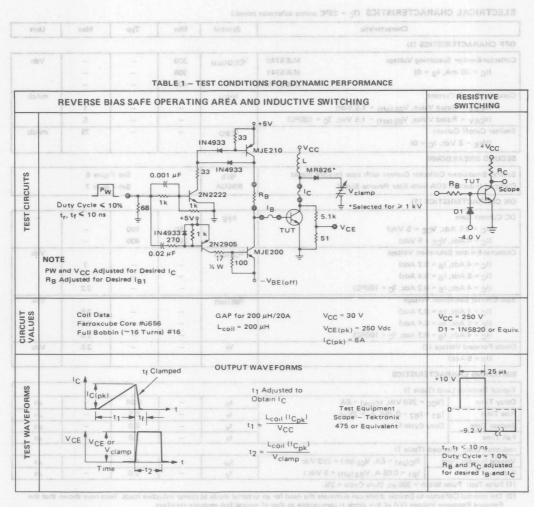
<sup>(2)</sup> The internal Collector-to-Emitter diode can eliminate the need for an external diode to clamp inductive loads. Tests have shown that the Forward Recovery Voltage (V<sub>f</sub>) of this diode is comparable to that of typical fast recovery rectifiers.



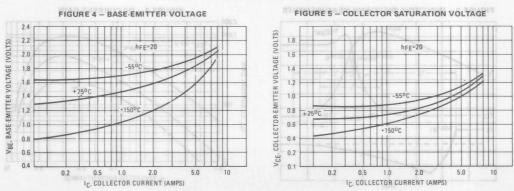








### TYPICAL CHARACTERISTICS





The Safe Operating Area figures shown in Figures 6 and 7 are specified ratings for these devices under the test conditions shown.

FIGURE 6 - FORWARD BIAS SAFE OPERATING AREA

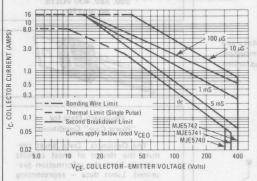
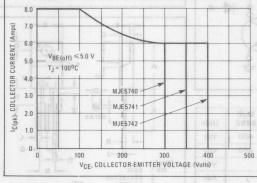


FIGURE 7 - REVERSE BIAS SAFE OPERATING AREA



### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

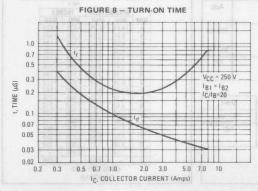
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

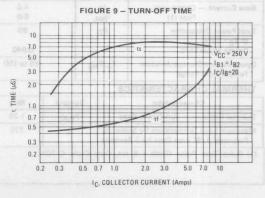
The data of Figure 6 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 6 may be found at any case temperature by using the appropriate curve on Figure 1.

#### REVERSE BIAS Some Tiled evisoubel an Out

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 7 gives the complete RBSOA characteristics.

### RESISTIVE SWITCHING PERFORMANCE





# **Designers Data Sheet**

### will do philbrish toward SWITCHMODE SERIES PNP SILICON POWER TRANSISTORS

The MJE5850, MJE5851 and the MJE5852 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as: 

- Switching Regulators
   Tobal of biles on stimil select
   Noverters when do nove 2 2025 K of name between
- Solenoid and Relay Drivers and attends for ob
  - Motor Controls
     Mo mworld separation and its inertials
  - Delfection Circuits

#### Fast Turn-Off Times

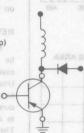
100 ns Inductive Fall Time @ 25°C (Typ) 125 ns Inductive Crossover Time @ 25°C (Typ)

Operating Temperature Range -65 to +150°C

100°C Performance Specified for: 60 9d days assess

Reversed Biased SOA with Inductive Loads Switching Times with Inductive Loads 0-House and Saturation Voltages amount and man 214Th promise

Leakage Currents duna OR paigmals suitos as



#### MAXIMUM RATINGS

Karugi abom erlonslavs ns i	Symbol	MJE 5850	MJE 5851	MJE 5852	Unit
Collector-Emitter Voltage	VCEO(sus)	300	350	400	Vdc
Collector-Emitter Voltage	VCEV	350	400	450	Vdc
Emitter Base Voltage	VEB		6.0		Vdc
Collector Current — Continuous Peak (1)	ICM JOW	8.0 AMROT 6116 HORMA			Adc
Base Current — Continuous Peak (1)	- e la Biara	4.0 8.0			Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	80			Watts
Derate above 25°C		0.640		W/°C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to 150		°C	

### THERMAL CHARACTERISTICS

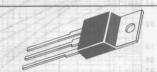
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.25	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 8 AMPERE

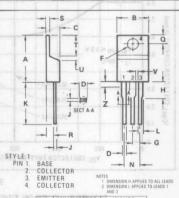
# PNP SILICON **POWER TRANSISTORS**

300, 350, 400 VOLTS 80 WATTS



#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design are sense an areas



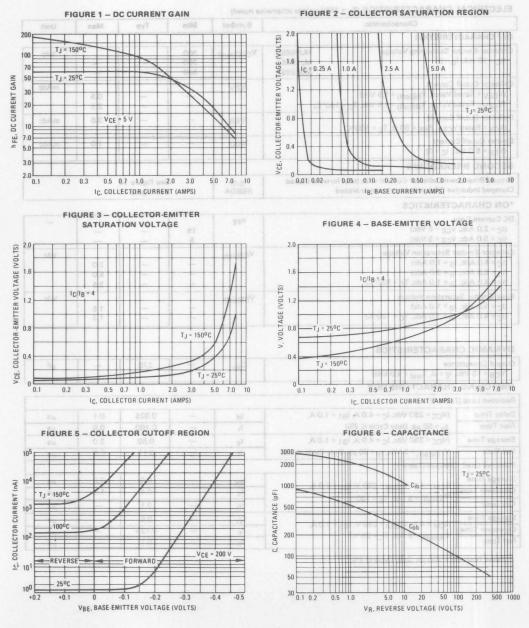
	MILLIM			INCHES		
DIM	MIN.	MAX	MIN	MAX		
A	14.60	15.75	0.575	0.620		
В	9.65	10.29	0.380	0.405		
C	4.06	4.82	0.160	0.190		
D	0.64	0.89	0.025	0.035		
F	3.61	3.73	0.142	0.147		
G	2.41	2.67	0.095	0.105		
H	2.79	3.93	0.110	0.155		
J	0.36	0.56	0.014	0.022		
K	12.70	14.27	0.500	0.562		
L	1.14	1.39	0.045	0.055		
N	4.83	5.33	0.190	0.210		
0	2.54	3.04	0.100	0.120		
R	2.04	2.79	0.080	0.110		
S	1.14	1.39	0.045	0.055		
T	5.97	6.48	0.235	0.255		
U	0.00	1.27	0.000	0.050		
V	1.14	3 - 1	0.045	-		
2	- 1	2.03	1 -	0.080		
0.5	CA	SE 221	A-02	0.0- 3		
	STOR T	O-220A	В			

### TYPICAL ELECTRICAL CHARACTERISTICS

	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACT	ERISTICS	1 1 67 8				HIL	-
Collector-Emitter (I <sub>C</sub> = 10 mA, I <sub>E</sub>	Sustaining Voltage	MJE5850 MJE5851 MJE5852	VCEO(sus)	300 350 400			Vdc
	Current Value, VBE(off) = 1.5 Vdc) Value, VBE(off) = 1.5 Vdc, T <sub>C</sub> =	100°C)	ICEV	4		0.5 2.5	mAdc
Collector Cutoff ( (VCE = Rated V	Current CEV, R <sub>BE</sub> = 50 Ω, T <sub>C</sub> = 100°C)	3.0 13 20	ICER		_   V 8 /	3.0	mAdc
Emitter Cutoff Co (VEB = 6.0 Vdc		A0 E	IEBO			1.0	mAdc
SECOND BRE	AKDOWN	1 8					
	wn Collector Current with base we SOA with base reverse biase		IS/b RBSOA		See Figure 12 See Figure 13		1 8.2
*ON CHARAC	CTERISTICS						
DC Current Gain (I <sub>C</sub> = 2.0 Adc, \(I <sub>C</sub> = 5.0 Adc, \)	/ <sub>CE</sub> = 5 Vdc)	PIGU	hFE	15 5	ION VOLTAX	SATURAT	_
Collector-Emitte (I <sub>C</sub> = 4.0 Adc, I (I <sub>C</sub> = 8.0 Adc, I	r Saturation Voltage B = 1.0 Adc)		VCE(sat)			2.0 5.0 2.5	Vdc
Base-Emitter Sa (I <sub>C</sub> = 4.0 Adc, I (I <sub>C</sub> = 4.0 Adc, I		\$1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	V <sub>BE</sub> (sat)	DPBBY - LT		1.5 1.5	Vdc
DYNAMIC CH	HARACTERISTICS						
Output Capacita (V <sub>CB</sub> = 10 Vdc	nce , I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	Mel v (T	Cob	= 17	270		pF
SWITCHING	CHARACTERISTICS	\$.0 t.0	81 81 02	0.6 0.	5 61 11	0.3 0.5	1 0.2
Resistive Load (T	able 4) FRERRUS ROTUELIOS, 51			AMPS)	THERRUD HOTE	133163 31	
Delay Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 4.0 A, I <sub>B</sub>	1 = 1.0 A,	t <sub>d</sub>		0.025	0.1	μS
Rise Time	$t_p = 50 \mu s$ , Duty Cycle $\leq 2\%$ )		t <sub>r</sub>	иотовя я	0.100	0.5	μS
Storage Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 4.0 A, I <sub>B</sub>		ts	-	0.60	2.0	μS
Fall Time	$V_{BE(off)} = 5 \text{ Vdc}, t_p = 50 \mu s, l$	Duty Cycle ≤ 2%)	tf		0.11	0.5	μS
1000	Clamped (Table 1)	10003					
Storage Time Crossover Time	(I <sub>CM</sub> = 4 A, V <sub>CEM</sub> = 250 V, I <sub>B</sub>	1 = 1.0 A, 0001	t <sub>SV</sub>	4=1	0.8	3.0 1.5	μS
Fall Time	VBE(off) = 5 Vdc, T <sub>C</sub> = 100°C)	# Soo ##	tfi	7-1	0.1		μS
Storage Time			t <sub>sv</sub>		0.5	X-	μѕ
Crossover Time	(I <sub>CM</sub> = 4 Å, V <sub>CEM</sub> = 250 V, I <sub>B</sub>	1 = 1.0 A,	t <sub>c</sub>	-1-1	0.125		μS
	VBE(off) = 5 Vdc, T <sub>C</sub> = 25°C)		1fi I		0.1		иѕ

Ver. BASE EMITTER VOLTAGE (VOLTE)

# TYPICAL ELECTRICAL CHARACTERISTICS



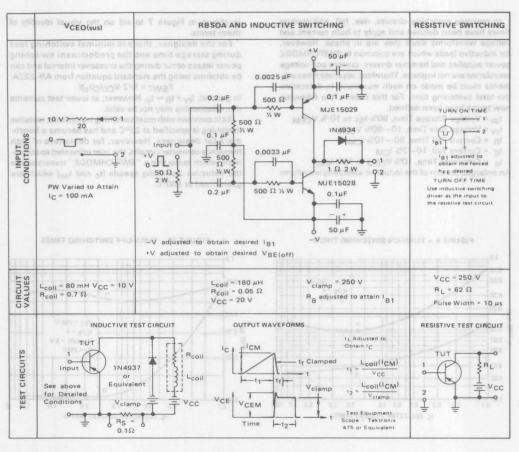


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

### FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

1.0 tc 10000 1c = 4 A 0.8 1c/1B = 4 TJ = 25°C 0.6 t<sub>SV</sub>100°C 90% IB1 VCEM FICM VCE tsv25°C 0.4 IC -0.2 tr 25°C 90% CM TIME VBE (off), BASE-EMITTER VOLTAGE (VOLTS)

FIGURE 8 - INDUCTIVE SWITCHING TIMES

2.7

2.4

0.6

0.3

# SWITCHING TIMES NOTE TO BURNE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10 % VCEM

trv = Voltage Rise Time, 10—90% VCEM

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10—2% ICM

t<sub>C</sub> = Crossover Time, 10% VCEM to 10% ICM

An enlarged portion of the inductive switching waveform

is shown in Figure 7 to aid on the visual identity of these terms.

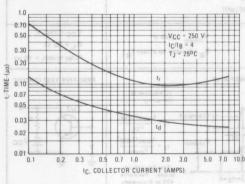
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

PSWT = 1/2 VCClCtc/f

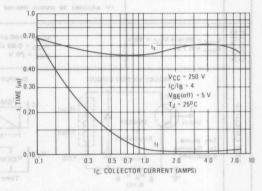
In general,  $t_{rV}+t_{fi}\simeq t_C$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user orinented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\rm C}$  and  $t_{\rm SV}$ ) which are guaranteed at 100°C.

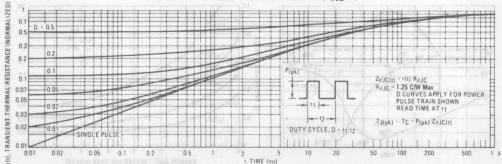




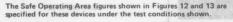
### FIGURE 10 - TURN-OFF SWITCHING TIMES

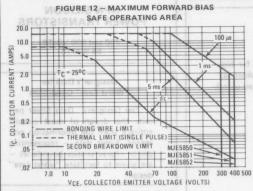


#### FIGURE 11 – TYPICAL THERMAL RESPONSE $[Z_{\theta JC}(t)]$

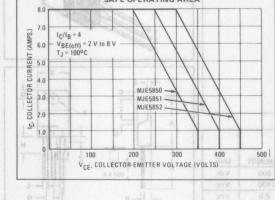








### FIGURE 13 - RBSOA, MAXIMUM REVERSE BIAS SAFE OPERATING AREA



### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

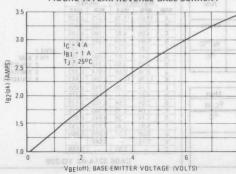
The data of Figure 12 is based on TC = 25°C; TJ(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 15

TJ(pk) may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

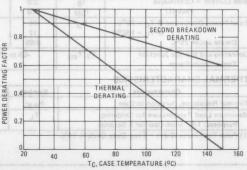
### Operating Temperature Range -65 to Reverse

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the RBSOA characteristics.

#### FIGURE 14 PEAK REVERSE BASE CURRENT



#### FIGURE 15 - FORWARD BIAS POWER DERATING



# Designers Data Sheet

### valide professed several SWITCHMODE SERIES brodes bre & NPN SILICON POWER TRANSISTORS

The MJE8500 and MJE8501 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators S • Inverters Disard brooms 2985 S gT madw bassing

  - Solenoid and Relay Drivers
- Motor Controls The Market Vid Studies and Controls The Motor Controls The Market Vid Studies and Controls The Motor Control C
  - Deflection Circuits

Fast Turn-Off Times

300 ns Inductive Fall Time - 25°C (Typ) 500 ns Inductive Crossover Time - 25°C (Typ) 900 ns Inductive Storage Time - 25°C (Typ)

Operating Temperature Range -65 to +125°C

100°C Performance Specified for:

Reversed Biased SOA with Inductive Loads

Switching Times with Inductive Loads or ble Saturation Voltages of select select

Two to Leakage Currents Hospita is world to its level state

### MAXIMUM RATINGS

ng reverse biased turn off. This clamped conditions so that the				
El anupi a Rating foneles na ot		MJE8500	MJE8501	Unit
Collector-Emitter Voltage	VCEO(sus)	700	800	Vdc
Collector-Emitter Voltage	VCEV	1200	1400	Vdc
Emitter Base Voltage	VEB	8.0	8.0	Vdc
Collector Current — Continuous Peak (1)	I <sub>C</sub> M	2.5 5.0	2.5 5.0	Adc
Base Current — Continuous Peak (1)	I <sub>B</sub>	2.0 4.0	2.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$	PD	65 17	65 17	Watts
Derate above 25°C		0.65	0.65	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+125	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.54	°C/W
Maximum Lead Temperature for Soldering	TL	275	ос
Purposes: 1/8" from Case for 5 Seconds	0.2	19	

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

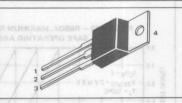
#### 2.5 AMPERE

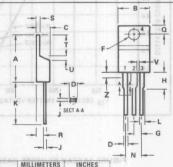
### NPN SILICON **POWER TRANSISTORS**

700 and 800 VOLTS 65 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design.

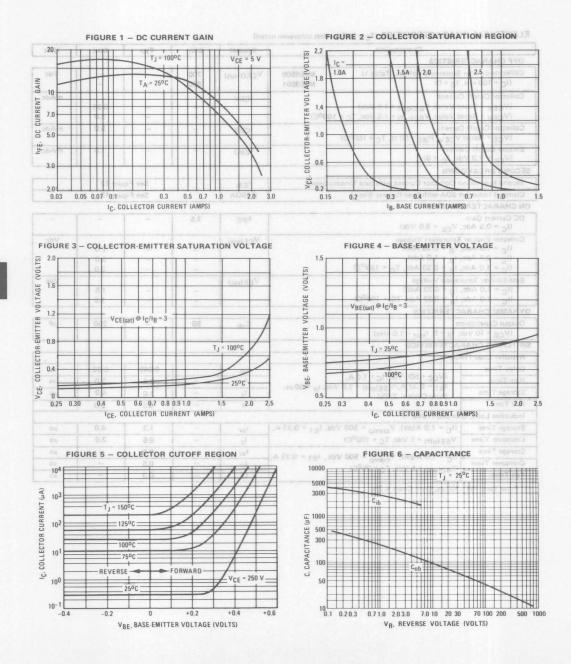


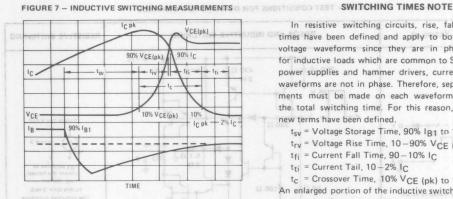


					10 1-
-	MILLIN	ETERS	INC	HES	1914
DIM	MIN	MAX	MIN	MAX	
A	14.60	15.75	0.575	0.620	
В	9.65	10.29	0.380	0.405	
C	4.06	4.82	0.160	0.190	
D	0.64	0.89	0.025	0.035	
E	3.61	3.73	0.142	0.147	STYLE 1
G	2.41	2.67	0.095	0.105	PIN 1 BASE
Н	2.79	3.93	0.110	0.155	2 COLLECTOR
J	0.36	0.56	0.014	0.022	3. EMITTER
K	12.70	14.27	0.500	0.562	4. COLLECTOR
L	1.14	1.39	0.045	0.055	
N	4.83	5.33	0.190	0.210	
Q	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	
T	5.97	6.48	0.235	0.255	
U	0.00	1.27	0.000	0.050	
٧	1.14	-	0.045	-	

2.03 - 0.080 CASE 221A-02 TO-220

	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACT	ERISTICS	2	V 6 = 30 V		001-11		
Collector-Emitter	Sustaining Voltage (Table 1)	MJE8500	VCEO(sus)	700			Vdc
(I <sub>C</sub> = 100 mA		MJE8501	CLO(sus)	800	3985 -AT		1
Collector Cutoff		- 1	ICEV				mAde
	ed Value, V <sub>BE(off)</sub> = 1.5 Vdc)	3	CEV			0.25	
	ed Value, VBE(off) = 1.5 Vdc, TC = 100°C			filt-	11-1-1	5.0	7.0
Collector Cutoff	Current	85	ICER	111		5.0	mAde
(VCE = Rated	VCEV, RBE = 50 Ω, TC = 100°C)		1//				III III III
Emitter Cutoff C (V <sub>EB</sub> = 7.0 V		1307	IEBO			1.0	mAd
SECOND BREAKI	NOOWN	20	1				
Second Breakdov	on Collector Current with base forward bias	sed	Is/b		See Fi	igure 12	
Clamped Inductiv	ve SOA with Base Reverse Biased	0.1	RBSOA	0.5 0.7 1	See Fi	igure 13	0.03 0.0
	ISTICS (1) HUD BOAR of			CRE (MINES)			
DC Current Gain			hFE	7.5	-	-	T
	c, V <sub>CE</sub> = 5.0 Vdc)						
Collector-Emitte	Saturation Voltage	7 9 5 18	VCE(sat)	0.4.			Vdc
	c, I <sub>B</sub> = 0.33 Adc)		DA P.JOS S	SATURATI	RETTIME-RO	2.0	GURE 3
(I <sub>C</sub> = 2.5 Ad	e, I <sub>B</sub> = 1.0 Adc)				1 1-1	5.0	1 25
	e, $I_B = 0.33 \text{ Adc}, T_C = 100^{\circ}\text{C}$	8				3.0	
Base-Emitter Sat		100	VBE(sat)			4.5	Vdc
	c, I <sub>B</sub> = 0.33 Adc) c, I <sub>B</sub> = 0.33 Adc, TC = 100°C)					1.5	
DYNAMIC CHAR		-				1.0	2.1
Output Capacitar		2	C . I	50	1 0 8/010/0	250	l pF
	dc, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	20	Cob	30		250	Pr
SWITCHING CHA		-	39881				1 0.0
Resistive Load (7	SHOULD SEE STORY OF STREET	-	2 3 383 - 1				-
Delay Time		-	t <sub>d</sub>		0.045	0.20	l us
Rise Time	(V <sub>CC</sub> = 500 Vdc, I <sub>C</sub> = 1.0 A,	4			0.045	2.0	μς
Storage Time	IB1 = 0.33 A, VBE(off) = 5.0 Vdc, tp	$_{0} = 50 \mu s$ ,	t <sub>ress</sub>		The state of the s	4.0	- Control of
Fall Time	Duty Cycle ≤ 2.0%)		ts	110	1.0	the standard standard	μs
	Name of the State	-	tf	2888 AT TWIT	0.5	2.0	μς
The second second	Clamped (Table 1)	0.00 4		ASSESSED THESE	1.0	Jul 33	1
Storage Time	(I <sub>C</sub> = 1.0 A(pk), V <sub>clamp</sub> = 500 Vdc, I <sub>E</sub>	31 = 0.33 A,	t <sub>sv</sub>		1.3	4.0	μς
Crossover Time	V <sub>BE(off)</sub> = 5 Vdc, T <sub>C</sub> = 100°C)		t <sub>c</sub>		0.6	2.0	μs
Storage Time	(I <sub>C</sub> = 1.0 A(pk), V <sub>clamp</sub> = 500 Vdc, I <sub>8</sub>	B1 = 0.33 A,	t <sub>sv</sub> work	MAR THOTU	0.9	00 - E BRU	μs μs
Crossover Time	VBE(off) = 5 Vdc, TC = 25°C)	101 GE	t <sub>C</sub>		0.5		μs
Fall Time	B - CHILLE - CHREEFER	A	tfi	13.7	0.3	-	μs
1) Pulse Test: PW	- 300 μs, Duty Cycle ≤ 2%.						
				BB		921 - 1 - 1 - 1 - 1 - 1	
			1	1-1		101 - F1	
				1			
						001	
		-					
				H			





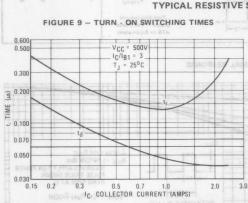


IC = 1.0 A

CURRENT (AMPS)

BASE

(pk) 182 ( IB1 = 0.33 A



VBE (Off), BASE EMITTER VOLTAGE (VOLTS)

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined. t<sub>sv</sub> = Voltage Storage Time, 90% IB1 to 10% VCE (pk)

trv = Voltage Rise Time, 10-90% VCE (pk)

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>CE</sub> (pk) to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $P_{SWT} = 1/2 V_{CC} I_{C}(t_{c}) f$ 

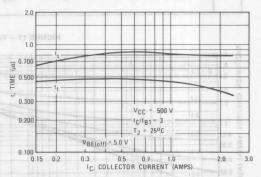
In general,  $t_{rv} + t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $(t_C \text{ and } t_{SV})$  which are guaranteed at 100°C.

### TYPICAL RESISTIVE SWITCHING PERFORMANCE

8.0

FIGURE 10 - TURN - OFF SWITCHING TIMES





0.01

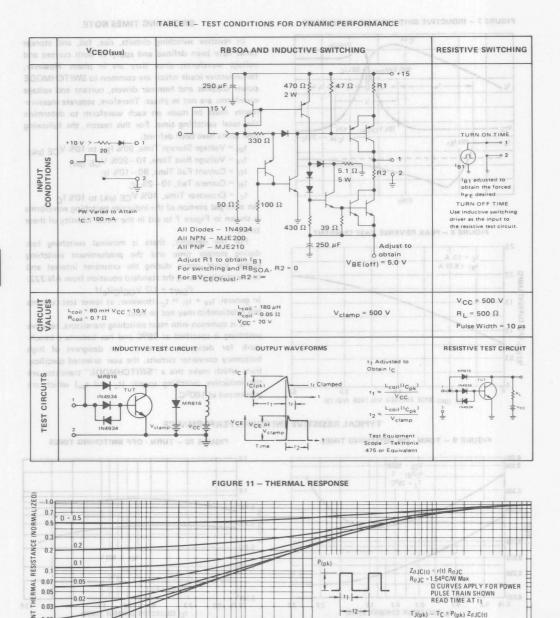
3

0.02

0.05

0.2

0.5



3-1164

t, TIME (ms)

DUTY CYCLE, D = t1/t2

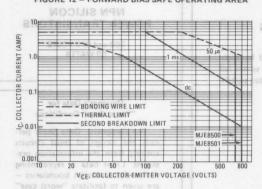
10

50 100 200

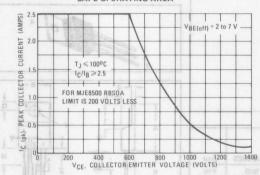
500 1.0 k



#### FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



### SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

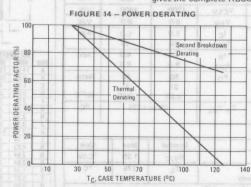
There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C$  = 25°C;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives the complete RBSOA characteristics.



# Designers Data Sheet

### villeds gariboard sewood a SWITCHMODE SERIES bnoose bns stuling SILICON POWER TRANSISTORS preakdown. Safe operating area curves indicate IC-VCE

The MJE8502 and MJE8503 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmwo mode applications such as: a no gnibroseb eldenev as

- Switching Regulators Switching Regulators
   Inverters
- Solenoid and Relay Drivers agestlov and is manual
- no sie Motor Controls is gaiste ve anutanagmas ases you to
  - Deflection Circuits
     Deflection Circuits
     Deflection Circuits

Fast Turn-Off Times

150 ns Inductive Fall Time-25°C (Typ)

400 ns Inductive Crossover Time-25°C (Typ)

1200 ns Inductive Storage Time-25°C (Typ)

Operating Temperature Range -65 to +125°C

100°C Performance Specified for:

Reverse-Biased SOA with Inductive Loads

Switching Times with Inductive Loads Saturation Voltages

Leakage Currents 2000 6 world to 14 level size 8 rent. This can be accomplished by several means such as

### MAXIMUM RATINGS

ring reverse biased turn-off. This	it sidswell	consistion		1
clamped conditions so that the dot on avalancigniteBde. Figure 13	Symbol	MJE8502	MJE8503	Unit
Collector-Emitter Voltage 1979-1870 AC	VCEO(sus)	700	800	Vdc
Collector-Emitter Voltage	VCEV	1200	1400	Vdc
Emitter Base Voltage	VEB	8.0	8.0	Vdc
Collector Current - Continuous Peak (1)	I <sub>C</sub> M	5.0	5.0	Adc
Base Current — Continuous Peak (1)	I <sub>B</sub>	4.0 8.0	4.0 8.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $25^{\circ}C$	PD	80 21 0.80	80 21 0.80	Watts W/°C
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-65 to	+125	°C

#### THERMAL CHARACTERISTICS

Symbol	Max	Unit
R <sub>θ</sub> JC	1.25	°C/W
(III) T <sub>L</sub>	275	°C °C
		R <sub>θ</sub> JC 1.25

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

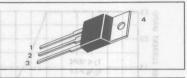
#### 5.0 AMPERE

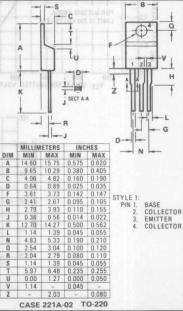
### NPN SILICON **POWER TRANSISTORS**

700 and 800 VOLTS 80 WATTS

#### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries are given to facilitate "worst case" design. THE ACCES - ET TRUDIS

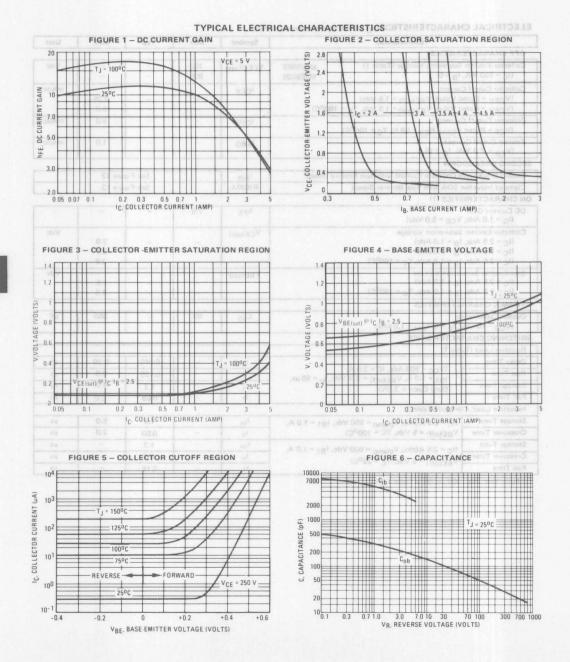




FIFOTDICAL	CHADACTEDICTION	/m ==0=	o a street or a section of
ELECTRICAL	CHARACTERISTICS	(1c = 25°C	unless otherwise noted)

ION REGION	Cital actoristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTE					III	1   65
Collector-Emitter	Sustaining Voltage (Table 1) MJE8 MJE8 MJE8		700 800		00001 7	Vdc
Collector Cutoff	Current	ICEV	1		2020	mAd
	ed Value, V <sub>BE(off)</sub> = 1.5 Vdc) ed Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)				0.25 5.0	
Collector Cutoff		ICER		-	5.0	mAd
	$V_{CEV}$ , $R_{BE} = 50 \Omega$ , $T_{C} = 100^{\circ}C$					11 102
Emitter Cutoff Co		IEBO		-	1.0	mAd
SECOND BREAKE	DOWN	1	1 111			1
Second Breakdow	vn Collector Current with base forward biased	IS/b		See F	igure 12	1111
Clamped Inductiv	ve SOA with Base Reverse Biased	RBSOA		See F	igure 13	l lar
ON CHARACTERI	ISTICS (1)	2 2 5	1 4.0	0.0 £.0	10 10	10 0 20 0
DC Current Gain (IC = 1.0 Adc,	, V <sub>CE</sub> = 5.0 Vdc)	pŁE	7.5	000.00123330		
(I <sub>C</sub> = 2.5 Adc,	Saturation Voltage , I <sub>B</sub> = 1.0 Adc)	VCE(sat)			2.0	Vdc
(I <sub>C</sub> = 5.0 Adc,	(I <sub>B</sub> = 2.0 Adc) 32A8 - 4.3AU014	Notasu not	RAPUTAS	BTTIME 80	3.0	BRURE
	, I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100°C)		THE	TTT	3.0	1110
Base-Emitter Satu		VBE(sat)			1.5	Vdc
	, I <sub>B</sub> = 1.0 Adc) , I <sub>B</sub> = 1.0 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)				1.5 1.5	
DYNAMIC CHARA					1.0	
Output Capacitan		Cob	60		300	l pF
	Ic, I <sub>E</sub> = 0, f <sub>test</sub> = 1.0 kHz)	000	- 00		300	1-1-18
SWITCHING CHAI						
Resistive Load (T	able 1)					
Delay Time		t <sub>d</sub>		0.040	0.20	μs
Rise Time	(V <sub>CC</sub> = 500 Adc, IC = 2.5 A,			0.125	2.0	μѕ
Storage Time	IB1 = 1.0 A, VBE(off) = 5.0 Vdc, t <sub>p</sub> = 50 Duty Cycle ≤ 2.0%)	μs, t <sub>s</sub>		1.2	4.0	μѕ
Fall Time	Duty Cycle < 2.0%)	tf		0.65	2.0	μѕ
Inductive Load, C	Clamped (Table 1)	1 5 5	111	8.0 5.0	50 10	80.0
Storage Time	(I <sub>C</sub> = 2.5 A(pk), V <sub>clamp</sub> = 500 Vdc, I <sub>B1</sub> = 1.0	O.A. t <sub>sv</sub>	WALTELIAND	1.6	5.0	μs
Crossover Time	V <sub>BE(off)</sub> = 5 Vdc, TC = 100°C)	tc		0.60	2.0	μs
Storage Time			-	1.2	-	μs
Crossover Time	(I <sub>C</sub> = 2.5 A(pk), V <sub>clamp</sub> = 500 Vdc, I <sub>B1</sub> = 1.0	t <sub>c</sub> MOI	DON TROT	0.4	20 - 2-380	μs
Fall Time	VBE(off) = 5 Vdc, T <sub>C</sub> = 25°C)	tfi	_	0.15		us
(1) Pulse Test: PW	- 300 µs, Duty Cycle ≤ 2%.	1 11		0.10	1	
			11			
					30361	
			-		39001	-
						0
					- 3283V38	
						1





#### SWITCHING TIMES NOTE

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

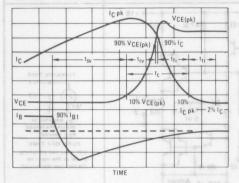
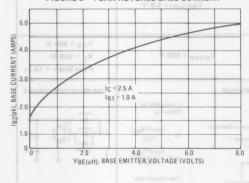


FIGURE 8 - PEAK REVERSE BASE CURRENT



In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% VCE(pk)

t<sub>rv</sub> = Voltage Rise Time, 10 – 90% VCE(pk)

 $t_{fi}$  = Current Fall Time, 90 – 10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% VCE(pk) to 10% IC An enlarged portion of the inductive switching waveforms

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $P_{SWT} = 1/2 V_{CC} I_{C}(t_{c}) f$  $t_{fi} \simeq t_{c}$ . However, at lower test current

In general,  $t_{rv}$  +  $t_{fi} \simeq t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t<sub>C</sub> and t<sub>SV</sub>) which are guaranteed at 100°C.

TYPICAL RESISTIVE SWITCHING PERFORMANCE

FIGURE 9 - TURN-ON SWITCHING TIMES

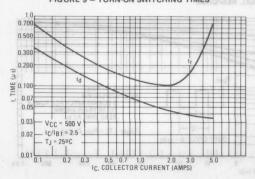
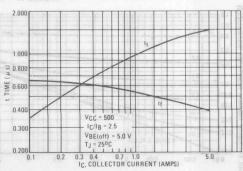
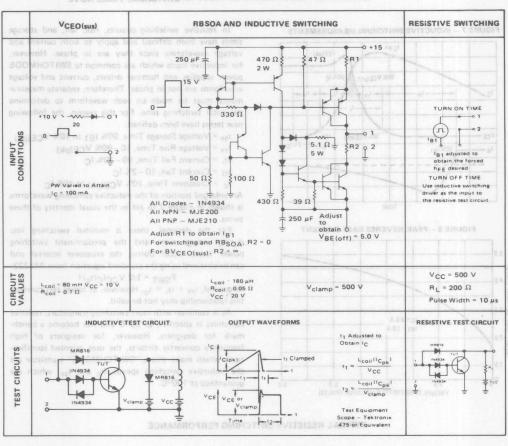
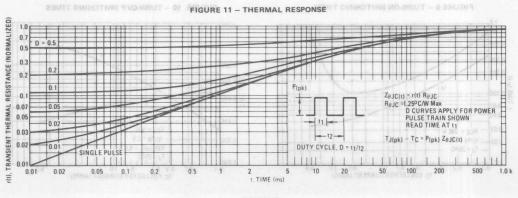


FIGURE 10 - TURN-OFF SWITCHING TIMES



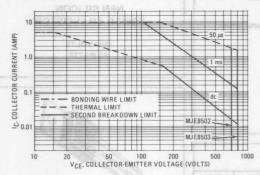
STOM SEMIT TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE



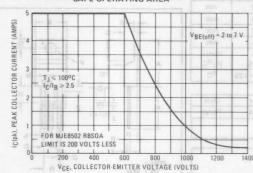


#### SAFE OPERATING AREA INFORMATION

### FIGURE 12 - FORWARD BIAS SAFE OPERATING AREA



#### FIGURE 13 – RBSOA, REVERSE BIAS SWITCHING SAFE OPERATING AREA



# FORWARD BIAS PLANT LATINOSTROM

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation: i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

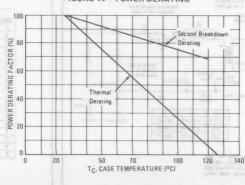
The data of Figure 12 is based on  $T_C = 25^{\circ}C$ ;  $T_J(pk)$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations, Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

T<sub>J(pk)</sub> may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode, Figure 13 gives the complete RBSOA characteristics.

FIGURE 14 - POWER DERATING





### HORIZONTAL DEFLECTION TRANSISTOR

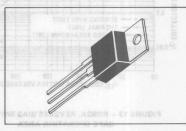
... specifically designed for use in small screen black and white deflection circuits.

- Collector-Emitter Voltage VCEX = 1500 Volts
- Glassivated Base-Collector Junction
  - Switching Times with Inductive Loads tf = 0.65 μs (Typ) @ I<sub>C</sub> = 2.0 A

### 2.5 AMPERE

NPN SILICON POWER TRANSISTOR

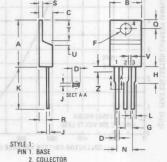
> **1500 VOLTS** 65 WATTS



MAXIMUM RATINGS			
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO(sus)	750	Vdc
Collector-Emitter Voltage	VCEX	1500	Vdc
Emitter-Base Voltage	VEBO	5.0	Vdc
Collector Current — Continuous	IC	2.5	Adc
Base Current - Continuous	For aldustii	2.0	Adc
Emitter Current - Continuous	sustanted sin	4.5	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	seedPot rig	65 0.65	Watts W/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T. Teto	-65 to +125	ос

### THERMAL CHARACTERISTICS

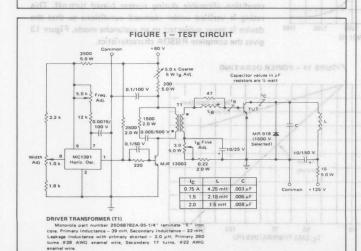
edT .ote prin Characteristic pridding	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Rejc	1.54	°C/W



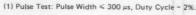
3. EMITTER 4. COLLECTOR

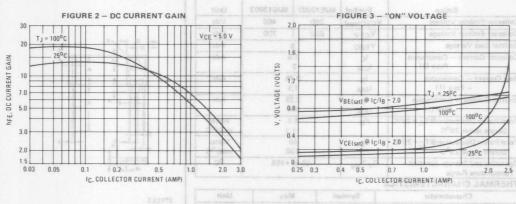
	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	-1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

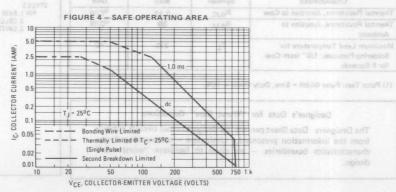
CASE 221A-02



Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS (1)					
Collector-Emitter Sustaining Voltage (I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 0)	VCEO(sus)	750	a donalu	nTH92	Vdc
Collector Cutoff Current (VCE = 1500 Vdc, VBE = 0)	ICES	RANISTSTORS	T RETVOY	NPN SILICON	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)				0.1	mAdc
ON CHARACTERISTICS (1)	dons such as	tanilona 3GGMi	D V SWITCH	or 115 and 22	I Seting
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 1.8 Adc)		or Colmols, S	overten, Moi		Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 1.8 Adc)	V <sub>BE</sub> (sat)		-8361	1.5	Vdc
DYNAMIC CHARACTERISTICS	200	Of = oT @ abso.	into Inductive I	w AO2 head so w	mys R e
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)	Cob			geidothe2 svite	pF <sub>a</sub>
Current Gain — Bandwidth Product (1) (I <sub>C</sub> = 0.1 Adc, V <sub>CE</sub> = 5.0 Vdc, f <sub>test</sub> = 1.0 MHz)	fΤ	-noisma		/ Blocking Capat and Switching A	MHz
SWITCHING CHARACTERISTICS					
Fall Time	tf				μs
(I <sub>C</sub> = 2.0 Adc, I <sub>B1</sub> = 1.0 Adc, L <sub>B</sub> = 12 μH)		_	0.65	1.0	









# Designers Data Sheet

### SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE applications such as Switching Regulators, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

### SPECIFICATION FEATURES:

- Reverse Biased SOA with Inductive Loads @ T<sub>C</sub> = 100°C
- Inductive Switching Matrix 0.5 to 1.5 Amp, 25 and 100°C ... t<sub>C</sub> @ 1 A, 100°C is 290 ns (Typ).
- 700 V Blocking Capability
- SOA and Switching Applications Information.

#### **MAXIMUM RATINGS**

Rating	Symbol	MJE13002	MJE13003	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEV	600	700	Vdc
Emitter Base Voltage	VEBO		9	Vdc
Collector Current - Continuous - Peak (1)	I <sub>C</sub>	1.5		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub> M	0.75		Adc
Emitter Current — Continuous — Peak (1)	I <sub>EM</sub>	2.25 4.5		Adc
Total Power Dissipation@T <sub>A</sub> = 25°C Derate above 25°C	PD	1.4 11.2		Watts mW/ <sup>O</sup> C
Total Power Dissipation@T <sub>C</sub> = 25°C Derate above 25°C	er P <sub>D</sub>	40 320		Watts mW/ <sup>O</sup> C
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150		°C

### THERMAL CHARACTERISTICS

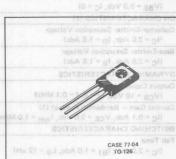
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	3.12	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	89	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

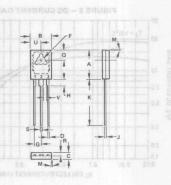
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data - representing device characteristics boundaries - are given to facilitate "worst case"

1.5 AMPERE NPN SILICON **POWER TRANSISTORS** 300 and 400 VOLTS 40 WATTS





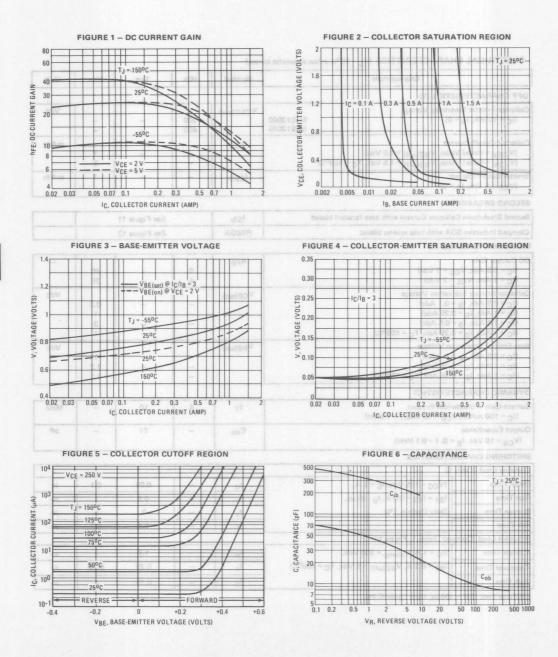
STYLE 3 PIN 1. BASE 2. COLLECTOR 3. EMITTER

			INCHES		
DIM	MIN	MAX	MIN	MAX	
A	10.80	11.05	0.425	0.435	
В	7.49	7.75	0.295	0.305	
C	2.41	2.67	0.095	0.105	
D	0.51	0.66	0.020	0.026	
F	2.92	3.18	0.115	0.125	
G	2.31	2.46	0.091	0.097	
Н	1.27	2.41	0.050	0.095	
J	0.38	0.64	0.015	0.025	
K	15.11	16.64	0.595	0.655	
M	3	30 TYP		YP	
0	3.76	4.01	0.148	0.158	
R	1.14	1.40	0.045	0.055	
S	0.64	0.89	0.025	0.035	
U	3.68	3.94	0.145	0.155	
٧	1.02	-	0.040	-	

MILLIMETERS INCHES

	Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS (1)		H J	2800		- 02
Collector-Emitter St	- ATT THAT ALL ALL DIST OF THE STATE OF THE	V <sub>CEO(sus)</sub>	1500			Vdc
(I <sub>C</sub> = 10 mA, I <sub>B</sub>			300 400			
		1.000	400	1033		mAdd
Collector Cutoff Cu	Value, V <sub>BE(off)</sub> = 1.5 Vdc)	ICEV			1	mAdd
(VCEV = Rated	Value, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)			4 5 - 30	- 5	
Emitter Cutoff Curr	ent	IEBO			1-1-	mAdd
(V <sub>EB</sub> = 9 Vdc, I	C = 0) 0 20 0 40 0 40 0 40 0		25 25	0.2	10.0 80.0	0.02 0.00
SECOND BREAKD	IB. BASE CURRENT NWO		NT (AMP)	SHRIP OF STREET	10, 00	
Second Breakdown	Collector Current with base forward biased	Is/b		See Figure 11		
Clamped Inductive	SOA with base reverse biased	RBSOA		See Figure 12		
ON CHARACTERIS	FIGURE 4 - COLLECTOR-EMITT (1) SOITS	36	ATJOV R	BASE EMITTE	- £ 3nuði	4
DC Current Gain	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	hFE	TIT		man	T =1
(I <sub>C</sub> = 0.5 Adc, V			8		40 25	
(I <sub>C</sub> = 1 Adc, V <sub>C</sub> Collector-Emitter Sa		Voru	1 Y 2 - 30	9 feet38V	20	Vdc
(Ic = 0.5 Adc, I	SAND TAXABLE AND ADMINISTRATION OF THE PARTY	VCE(sat)	-	+ + 1	0.5	Vac
(I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0.25 Adc)				D08817	1	+
(I <sub>C</sub> = 1.5 Adc, I <sub>I</sub> (I <sub>C</sub> = 1 Adc, I <sub>B</sub>			70.	3		
Base-Emitter Satura		V <sub>BE(sat)</sub>	110			Vdc
(IC = 0.5 Adc, I	3 = 0.1 Adc)	DEGGG	7-	3027	1-	-
(IC = 1 Adc, IB	Manager Transport Control of the Con			10027	1.2	-
DYNAMIC CHARA			3 20. 2	30.0	Tuna eu.a	Lucu, Mus
Current-Gain — Ban (I <sub>C</sub> = 100 mAdc	WCE = 10 Vdc, f = 1 MHz)	fT	(1) A THE	10	DI -	MHz
Output Capacitance		C <sub>ob</sub>	-	21	-	pF
	E = 0, f = 0.1 MHz)			UD ROTOBUJO		1012
SWITCHING CHAP		1000	DER STOR	O'S ROTOSSAN	NO - 0 20 P	MAN TO SERVICE
Resistive Load (Tab			77		V685 =	zeiV -
Delay Time	(V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 1 A,	td	17-7	0.05	0.1	μs
Rise Time	$I_{B1} = I_{B2} = 0.2 \text{ A}, t_p - 25 \mu s,$	tr	1 7 3	0.5	1	. µs
Storage Time	Duty Cycle ≤ 1%)	ts	1-1-1	2	4	μs
Fall Time		tf	1 -	0.4	0.7	μs
011111111111111111	mped (Table 1, Figure 13)				3085-	
Storage Time (I <sub>C</sub> = 1 A, V <sub>clamp</sub> = 300 Vdc,		t <sub>sv</sub>		1.7	4	μς
Crossover Time	Crossover Time I <sub>B1</sub> = 0.2 A, V <sub>BE(off)</sub> = 5 Vdc, T <sub>C</sub> = 100 <sup>o</sup> C)		1=	0.29	0.75	μs
	all Time			0.15		





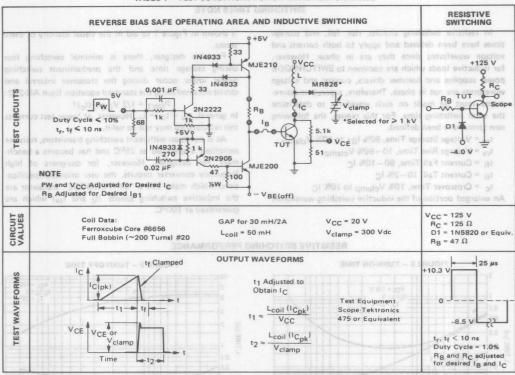


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

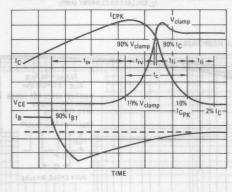


TABLE 2 - TYPICAL INDUCTIVE SWITCHING PERFORMANCE

I <sub>C</sub>	T <sub>C</sub> °C	t <sub>sV</sub> μs	t <sub>rv</sub> μs	tfi μs	<sup>t</sup> ti μs	t <sub>c</sub> μs
0.5	25	1.3	0.23	0.30	0.35	0.30
	100	1.6	0.26	0.30	0.40	0.36
1	25	1.5	0.10	0.14	0.05	0.16
	100	1.7	0.13	0.26	0.06	0.29
1.5	25	1.8	0.07	0.10	0.05	0.16
Day.	100	3	0.08	0.22	0.08	0.28

NOTE: All Data Recorded in the Inductive Switching Circuit in Table 1

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

try = Voltage Rise Time, 10-90% V<sub>clamp</sub>

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

tc = Crossover Time, 10% Vclamp to 10% IC

An enlarged portion of the inductive switching waveforms

is shown in Figure 7 to aid in the visual identity of these terms

MJE13002, MJE13003

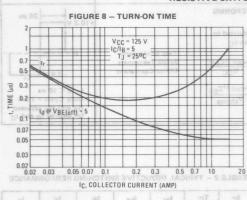
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

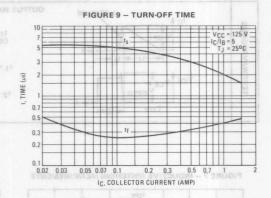
PSWT = 1/2 VCCIC(tc)f

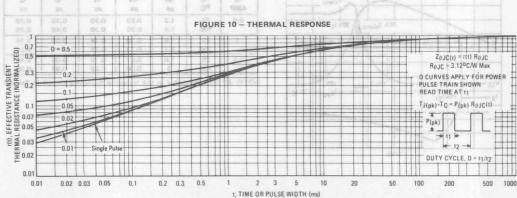
In general,  $t_{rv}+t_{fi}\simeq t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $(t_{\text{C}}$  and  $t_{\text{SV}})$  which are guaranteed at  $100^{\circ}\text{C}$ .

# RESISTIVE SWITCHING PERFORMANCE







# SAFE OPERATING AREA INFORMATION

## FORWARD BIAS TOOMHOTHER

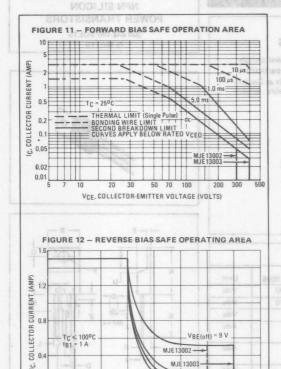
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on  $T_C=25^{o}C;\,T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{o}C.$  Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

T<sub>J(pk)</sub> may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

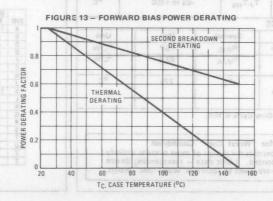
#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives RBSOA characteristics.



500

VCEV, COLLECTOR-EMITTER CLAMP VOLTAGE (VOLTS)







# Designers Data Sheet

# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE applications such as Switching Regulator's . Inverters, Motor Controls, Solenoid / Relay drivers and Deflection circuits.

## SPECIFICATION FEATURES:

- VCEO(sus) 400 V and 300 V
- Reverse Bias SOA with Inductive Loads @ T<sub>C</sub> = 100°C
- Inductive Switching Matrix 2 to 4 Amp, 25 and 100°C ... t<sub>c</sub> @ 3A, 100°C is 180 ns (Typ)
- 700 V Blocking Capability
- SOA and Switching Applications Information.

## **MAXIMUM RATINGS**

Rating	Symbol	MJE13004	MJE13005	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEV	600	700	Vdc
Emitter Base Voltage	VEBO	mbrill is	9	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub> M	est blad as 4 were		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	2 ca daux 4 mm		Adc
Emitter Current — Continuous — Peak (1)	I <sub>E</sub>	6		Adc
Total Power Dissipation@T <sub>A</sub> = 25°C Derate above 25°C	PD	2 16		Watts mW/OC
Total Power Dissipation@T <sub>C</sub> = 25°C Derate above 25°C	PD	75 600		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150		°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.67	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	ΤL	275	°C

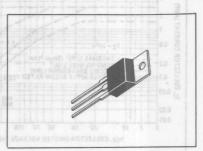
(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

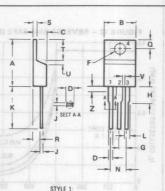
Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

# 4 AMPERE NPN SILICON **POWER TRANSISTORS**

300 and 400 VOLTS 75 WATTS





PIN 1. BASE 2 COLLECTOR COLLECTOR

	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

**CASE 221A-02** TO-220AB

# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

	Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERIS	TICS				1-1-1-1	
Collector-Emitter Sust (I <sub>C</sub> = 10 mA, I <sub>B</sub> =	0) MJ	VCEO(sus) E13005	300 400	# 85		Vdc
	ent ilue, VBE(off) = 1.5 Vdc) ilue, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 100 <sup>o</sup> C)	ICEV		<u>0</u> 288-	1 5	mAdo
Emitter Cutoff Curren (VEB = 9 Vdc, IC		IEBO	Mill	-	1	mAdo
SECOND BREAKDON	NN 8				and Voge - 5	-1:
Second Breakdown Co	llector Current with base forward biased	Is/b		See Figu	ure 11	II:
Clamped Inductive SO.	A with Base Reverse Biased	RBSOA	7 8.0	See Figu	re 12	8.04
ON CHARACTERIST	ICS					
DC Current Gain (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = (I <sub>C</sub> = 2 Adc, V <sub>CE</sub> =	5 Vdc) 5 Vdc) 183-801051100 - A 384019	hFE	10	- EXSE EMIT	60 40	-
Collector-Emitter Satur (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0 (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0 (I <sub>C</sub> = 4 Adc, I <sub>B</sub> = 1 (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0	.2 Adc) .5 Adc)	VCE(sat)		7= g(g) 8 V L= ggV 6	0.5 0.6 1 1	Vdc
Base-Emitter Saturation (I <sub>C</sub> = 1 Adc, I <sub>B</sub> = 0 (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0 (I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0	.2 Adc)	VBE(sat)		- 3085 - 3085 - 3085	1.2 1.6 1.5	Vdc
DYNAMIC CHARACT	ERISTICS		THE	strene		
Current-Gain — Bandw (I <sub>C</sub> = 500 mAdc, V	idth Product CE = 10 Vdc, f = 1 MHz)	f <sub>T</sub>	4	-		MHz
Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub>	= 0, f = 0.1 MHz)	C <sub>ob</sub>	1 12	65	1.0 80	pF
SWITCHING CHARAC	CTERISTICS		Liberta Petalan		0'	
Resistive Load (Table 2	2)					
Delay Time	(V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 2 A,	t <sub>d</sub> acres	BR STOTUS	0.025	0.1	μs
Rise Time	$I_{B1} = I_{B2} = 0.4 \text{ A}, t_p = 25 \mu s,$	tr		0.3	0.7	μs
Storage Time	Duty Cycle ≤ 1%)	t <sub>s</sub>	AFT	1.7	4	μς
Fall Time		tf	N-V	0.4	0.9	μs
Inductive Load, Clamp	ed (Table 2, Figure 13)		YENA		1992 441	
Voltage Storage Time	(I <sub>C</sub> = 2 A, V <sub>clamp</sub> = 300 Vdc,	t <sub>sv</sub>	1-1	0.9	4	μς
Crossover Time	$I_{B1} = 0.4 \text{ A}, V_{BE(off)} = 5 \text{ Vdc}, T_{C} = 100^{\circ}\text{C}$	t <sub>c</sub>	N 25	0.32	0.9	μs
Fall Time		t <sub>fi</sub>		0.16		μs

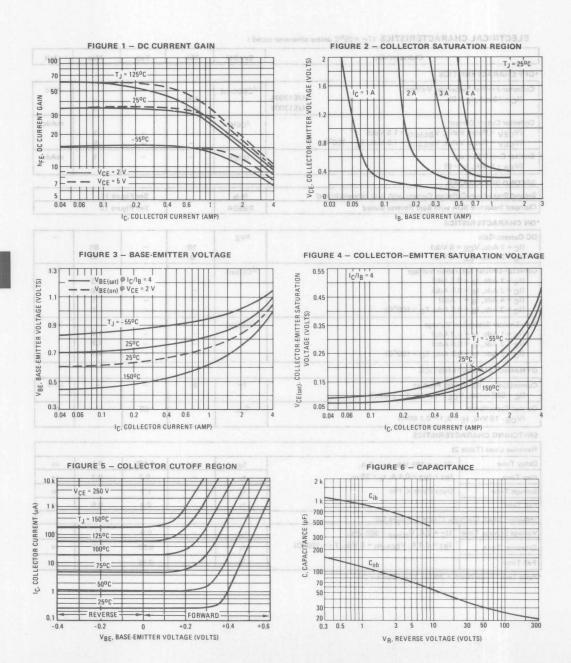


FIGURE 7 - INDUCTIVE SWITCHING MEASUREMENTS

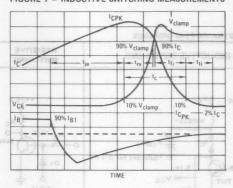


TABLE 1 - TYPICAL INDUCTIVE SWITCHING PERFORMANCE

I <sub>C</sub>	T <sub>C</sub> °C	t <sub>sv</sub>	t <sub>rv</sub>	tfi ns	t <sub>ti</sub>	t <sub>c</sub>
2	25	600	70	100	80	180
	100	900	110	240	130	320
3	25	650	60	140	60	200
	100	950	100	330	100	350
4	25	550	70	160	100	220
	100	850	110	350	160	390

NOTE: All Data recorded in the inductive Switching Circuit in Table 2.

#### **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

tsv = Voltage Storage Time, 90% IB1 to 10% Vclamp

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>c</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

 $P_{SWT} = 1/2 \ V_{CC} I_{C}(t_{c}) f$ In general,  $t_{rv} + t_{fi} \simeq t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

# RESISTIVE SWITCHING PERFORMANCE

FIGURE 8 - TURN-ON TIME

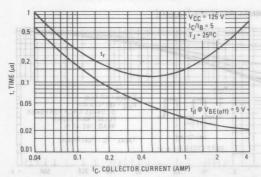
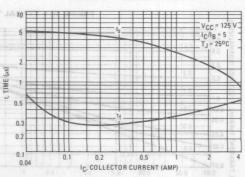
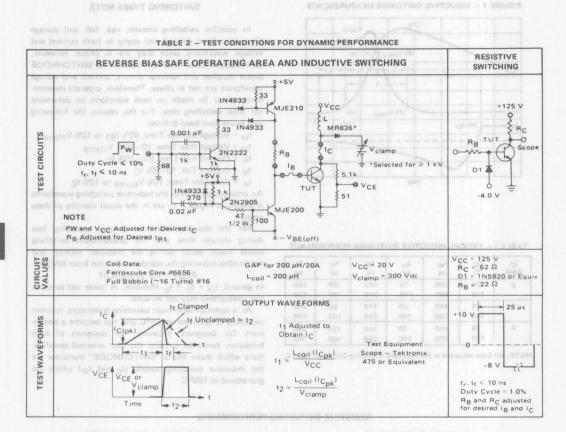
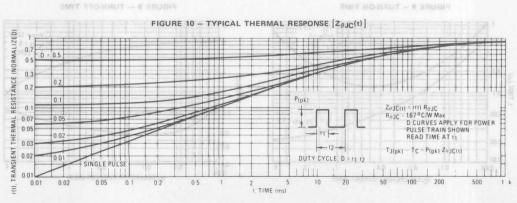


FIGURE 9 - TURN-OFF TIME



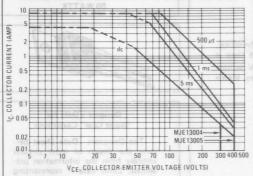




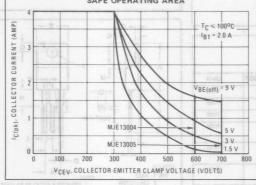


The Safe Operating Area Figures 11 and 12 are specified ratings for these devices under the test conditions shown.

#### FIGURE 11 - FORWARD BIAS SAFE OPERATING AREA



# SAFE OPERATING AREA



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

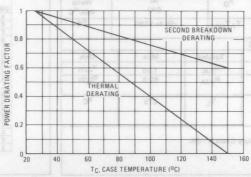
The data of Figure 11 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

T<sub>J</sub>(pk) may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete RBSOA characteristics.

FIGURE 13 - FORWARD BIAS POWER DERATING





# **Designers Data Sheet**

# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJE13006 and MJE13007 are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V switchmode applications such as Switching Regulators, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

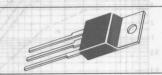
#### SPECIFICATION FEATURES: SO TO ONLY DOLLARD

- VCEO(sus) 400 V and 300 V
- Reverse Bias SOA with Inductive Loads @ T<sub>C</sub> = 100°C
  - Inductive Switching Matrix 3 to 8 Amp, 25 and 100°C
     ...t<sub>c</sub> @ 5A, 100°C is 136 ns (Typ).

     700 V Blocking Capability

  - SOA and Switching Applications Information.

8 AMPERE NPN SILICON **POWER TRANSISTORS** 300 and 400 VOLTS 80 WATTS



Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information pre-sented. Limit data — representing device characteristics boundaries – are given to facilitate "worst case" design.

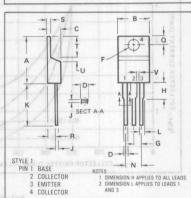
# MAXIMUM RATINGS

Rating	Symbol	MJE13006	MJE13007	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEV	600	700	Vdc
Emitter Base Voltage	VEBO	To clove end	9	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	8 8 16		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub> M	8		Adc
Emitter Current - Continuous - Peak (1)	IEM IEM	12 12 24 24		Adc
Total Power Dissipation@T <sub>A</sub> = 25°C Derate above 25°C	PD	2 16		Watts mW/ <sup>O</sup> C
Total Power Dissipation@T <sub>C</sub> = 25°C Derate above 25°C	PD	80 640		Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150		°c
	170	17.4571		1 10 10

# THERMAL CHARACTERISTICS

THERIVIAL CHARACTERISTICS			
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.56	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



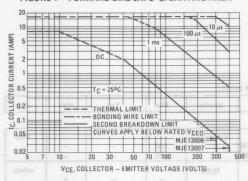
	MILLIN	IETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

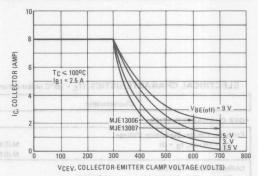
TO-220AB

			81 OF 81 OO				
	4-1-10						
					MILL		
ELECTRICAL CH	IARACTERISTICS (T <sub>C</sub> = 25°C unless of	herwise no	ted )				
ELECTITIONE OF	-/ <del>//// </del>	TIET VVISE TIO			10/61 - 314		
VE = moras V	Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERIS	TICS ABDECTION			TIME STATE	- HONDING WIRE U.		0.1
Collector-Emitter Sust			VCEO(sus)	DETAR WOLL	S A TANK SEAMON		Vdc
(IC = 10 mA, IB =		JE13006	F-1-1003	300		-11	11120
8 000 700 8	C 100" NO. THE NO. O	JE13007	209 200	400	26 34 50	-01	2 7
	Very Collector Autority Change		CEV	VOLTAGE	ATTIMA - NOTOBJI	00 35V	mAde
	alue, V <sub>BE(off)</sub> = 1.5 Vdc) alue, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)	iliosess and		9 ni n <u>v</u> orta	retugit s <u>o</u> vA golfa	Safe Cook	The
Emitter Cutoff Curren			IEBO	_		1	mAd
(VEB = 9 Vdc, IC			EBO				
SECOND BREAKDON	There are two limitations on the NV		DWITA	HEG REW	REPARD BIAS PA	RE3 - PC	UDIA
AND MADE AND ADDRESS OF THE PARTY OF THE PAR	llector Current with base forward biased	7	IS/b	1 - 1	See Figu	re 1	daen I
Clamped Inductive SOA with Base Reverse Biased			-		See Figu		
ON CHARACTERIST	operation; i.e., the transistor mi SOI		DINITARE OFFI	00038			
	greater dissipation than the curves ind	T	hee				
	The data of Figure 1 is be(abV 8		"FE	8		60	
(IC = 5 Adc, VCE =	5 Vdc) awag no pnibnagab aldainsv ai			5	12	30	1 8.
Collector-Emitter Satu	ration Voltage .4 Adc)		VCE(sat)		JAKRIH		Vdc
(I <sub>C</sub> = 2 Adc, I <sub>B</sub> = 0	4 Adc) 38 2 64 4 31 name deres	+	1111	117	Company and Angle	1	1-12
	Adc) need as since and alseled for ob Adc) o work as the voltages shown or correct	+		I		2	-
	Adc, T <sub>C</sub> = 100°C)	-	++-	4		3	
Base-Emitter Saturatio	n Voltage		V <sub>BE(sat)</sub>				Vdc
(IC = 2 Adc, IB = 0	Tu(pk) may be calculated (abA 4.					1.2	
	At high case temperatures, therr (abA	138	001	13 <sup>6</sup> 1 28 UT	TA, CASE TEMPERA	1.6	
CNAIG	Adc, T <sub>C</sub> = 100°C) and tent yewood end			1375 4891	1.C. CAS—1 CHRAGHS	1.5	
DYNAMIC CHARACT	ERISTICS						
(I <sub>C</sub> = 500 mAdc, V	idth Product (School and School a		fΤ	4	-	-	MHz
Output Capacitance (V <sub>CB</sub> - 10 Vdc, I <sub>E</sub>	= 0, f = 0.1 MHz)	MR3RT L	Cob a	380519	110	- 1	pF
SWITCHING CHARAC						7-11	
Resistive Load (Table	1)		7 14 14 1-			العالعال	0.5
Delay Time	(VCC = 125 Vdc, IC = 5 A,	-	t <sub>d</sub>		0.05	0.1	μs
Rise Time	I <sub>B1</sub> = I <sub>B2</sub> = 1 A, t <sub>D</sub> = 25 μs,		tr		0.8	1.5	μς
itorage Time	Duty Cycle ≤ 1%)	1	ts		1	3 10	μѕ
all Time	8 tin 11502 00 986 - 1150		tf		0.15	0.7	μs
T shame and vises of	ed (Table 1, Figure 13)			-	0.15	200	20.0
1118 371	(I <sub>C</sub> = 5 A, V <sub>clamp</sub> = 300 Vdc,				0.86	22	Test o
virage storage i line	vclamp - 300 vdc,		tev		0.00	2.3	μs
Crossover Time	IB1 = 1 A, VBE(off) = 5 Vdc, Tc = 100°C		tc		0.14	0.7	Sus



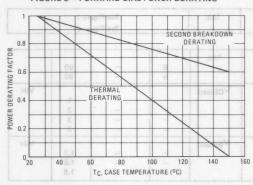






The Safe Operating Area figures shown in Figures 1 and 2 are specified ratings for these devices under the test conditions shown.

FIGURE 3 - FORWARD BIAS POWER DERATING

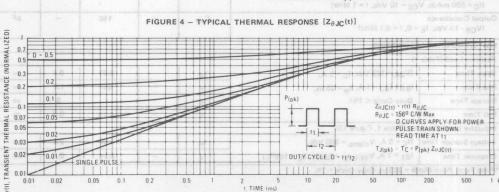


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

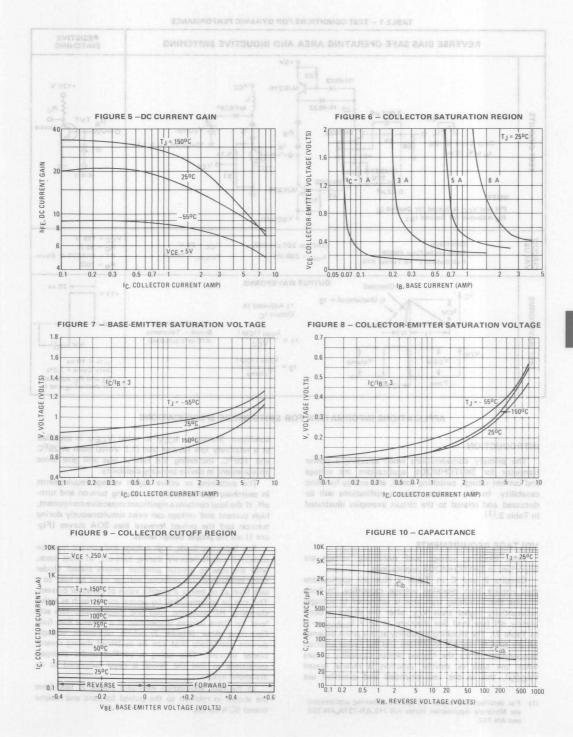
The data of Figure 1 is based on  $T_C=25^{o}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \geqslant 25^{o}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 1 may be found at any case temperature by using the appropriate curve on Figure 3.

TJ(pk) may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

Use of reverse biased safe operating area data (Figure 2) is discussed in the applications information section.







RESISTIVE REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING 33 IN4933 9Vcc MJE210 +125 V 33 IN4933 MR826 RC 0.001 µF CIRCUITS -0 2N2222 0-Duty Cycle ≤ 10% \*Selected for ≥ 1 kV DI t<sub>r</sub>, t<sub>f</sub> ≤ 10 ns TEST 5.1k IN4933 ¥ €1 k TUT 270 51 40 V 2N2905 MJE200 0.02 HF 100 PW and VCC Adjusted for Desired IC RB Adjusted for Desired IB1 VBE(off) CIRCUIT VCC = 125 V Coil Data: GAP for 200 µH/20A Vcc = 20 V  $R_C = 25 \Omega$ D1 = 1N5820 or Equiv Ferroxcube Core #6656 L<sub>coil</sub> = 200 μH V<sub>clamp</sub> = 300 V Full Bobbin (~16 Turns) #16  $R_B = 10\Omega$ **OUTPUT WAVEFORMS** te Clamped 25 µs IC 4 TEST WAVEFORMS t<sub>1</sub> Adjusted to Obtain IC Test Equipment Lcoil (ICM) Scope — Tektronix 475 or Equivalent VCC VCE VCEM V<sub>clamp</sub> Lcoil (ICM) tr. tf < 10 ns Duty Cycle = 1.0% V<sub>clamp</sub> RB and RC adjusted Time -t2desired IB and IC

TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

# APPLICATIONS INFORMATION FOR SWITCHMODE SPECIFICATIONS

# INTRODUCTION

The primary considerations when selecting a power transistor for SWITCHMODE applications are voltage and current ratings, switching speed, and energy handling capability. In this section, these specifications will be discussed and related to the circuit examples illustrated in Table 2.(1)

# **VOLTAGE REQUIREMENTS**

Both blocking voltage and sustaining voltage are important in SWITCHMODE applications.

Circuits B and C in Table 2 illustrate applications that require high blocking voltage capability. In both circuits the switching transistor is subjected to voltages substantially higher than  $V_{CC}$  after the device is completely off (see load line diagrams at  $I_{C}=I_{leakage}\approx 0$  in Table 2). The blocking capability at this point depends on the base to emitter conditions and the device junction temperature. Since the highest device capability occurs when the base to emitter junction is reverse biased (VCEV), this is the recommended and specified use

condition. Maximum I<sub>CEV</sub> at rated V<sub>CEV</sub> is specified at a relatively low reverse bias (1.5 Volts) both at 25°C and 100°C. Increasing the reverse bias will give some improvement in device blocking capability.

The sustaining or active region voltage requirements in switching applications occur during turn-on and turn-off. If the load contains a significant capacitive component, high current and voltage can exist simultaneously during turn-on and the pulsed forward bias SOA curves (Figure 1) are the proper design limits.

For inductive loads, high voltage and current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as a Reverse Bias Safe Operating Area (Figure 2) which represents voltage-current conditions that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

In the four application examples (Table 2) load lines are shown in relation to the pulsed forward and reverse biased SOA curves.

For detailed information on specific switching applications, see Motorola Application Notes AN-719, AN-737A, AN-767, and AN-752.

## **VOLTAGE REQUIREMENTS** (continued)

In circuits A and D, inductive reactance is clamped by the diodes shown. In circuits B and C the voltage is clamped by the output rectifiers, however, the voltage induced in the primary leakage inductance is not clamped by these diodes and could be large enough to destroy the device. A snubber network or an additional clamp may be required to keep the turn-off load line within the Reverse Bias SOA curve.

Load lines that fall within the pulsed forward biased SOA curve during turn-on and within the reverse bias SOA curve during turn-off are considered safe, with the following assumptions:

- (1) The device thermal limitations are not exceeded.
- (2) The turn-on time does not exceed 10 \(\mu\)s (see standard pulsed forward SOA curves in Figure 1).
- (3) The base drive conditions are within the specified limits shown on the Reverse Bias SOA curve (Figure 2).

# **CURRENT REQUIREMENTS**

An efficient switching transistor must operate at the required current level with good fall time, high energy

handling capability and low saturation voltage. On this data sheet, these parameters have been specified at 5 amperes which represents typical design conditions for these devices. The current drive requirements are usually dictated by the VCE(sat) specification because the maximum saturation voltage is specified at a forced gain condition which must be duplicated or exceeded in the application to control the saturation voltage.

# SWITCHING REQUIREMENTS

In many switching applications, a major portion of the transistor power dissipation occurs during the fall time (tfi). For this reason considerable effort is usually devoted to reducing the fall time. The recommended way to accomplish this is to reverse bias the base-emitter junction during turn-off. The reverse biased switching characteristics for inductive loads are discussed in Figure 11 and Table 3 and resistive loads in Figures 13 and 14. Usually the inductive load component will be the dominant factor in SWITCHMODE applications and the inductive switching data will more closely represent the device performance in actual application. The inductive switching characteristics are derived from the same circuit used to specify the reverse biased SOA curves, (See Table 1) providing correlation between test procedures and actual use conditions.

## RESISTIVE SWITCHING PERFORMANCE

FIGURE 11 - TURN-ON TIME

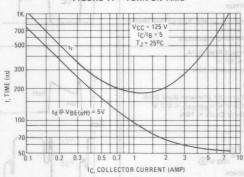


FIGURE 13 - INDUCTIVE SWITCHING MEASUREMENTS

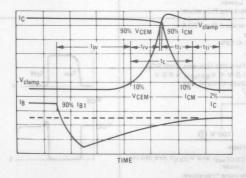


FIGURE 12 - TURN-OFF TIME

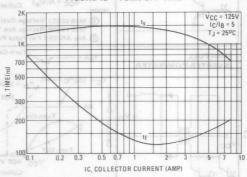


FIGURE 14 – TYPICAL INDUCTIVE SWITCHING WAVEFORMS
(at 300 V and 8A with I<sub>B1</sub> = 1.6A and V<sub>BE(off)</sub> = 5 V)

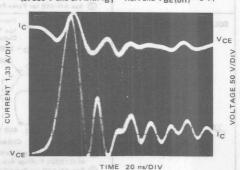
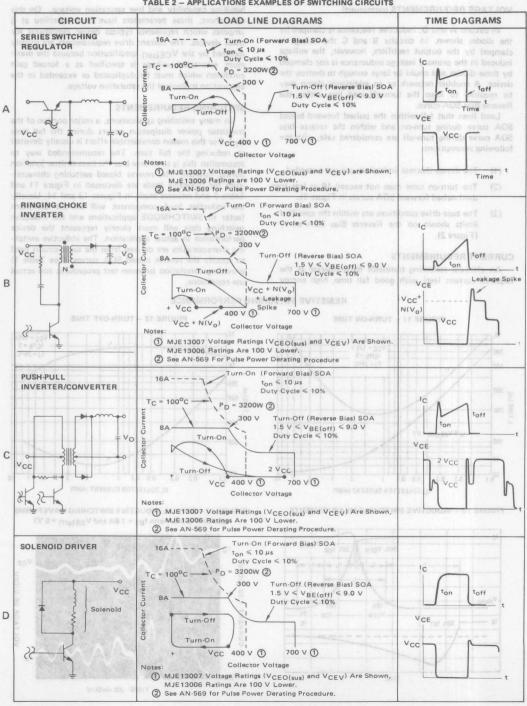


TABLE 2 - APPLICATIONS EXAMPLES OF SWITCHING CIRCUITS



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senied. Limit data - representing

#### TABLE 3 - TYPICAL INDUCTIVE SWITCHING PERFORMANCE

I <sub>C</sub>	T <sub>C</sub> °C	t <sub>sv</sub>	t <sub>rv</sub>	t <sub>fi</sub>	t <sub>ti</sub>	t <sub>c</sub>
3	25	730	115	100	110	200
-	100	1000	150	100	150	250
5	25	600	60	23	4	85
	100	860	84	50	10	136
8	25	650	25	26	4	42
	100	880	52	80	20	160

NOTE: All Data recorded in the inductive Switching Circuit in Table 1. If I AND 2 318 61199 R.

SWITCHING TIME NOTES

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms

t<sub>SV</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>CEM</sub>

t<sub>rv</sub> = Voltage Rise Time, 10-90% VCEM tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 13 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222A:

....t. @ 8 A. 1000C is 120 ns (Typ).

SOA and Switching Applications information.

PSWT = 1/2 VCCIC(tc) f

Typical inductive switching waveforms are shown in Figure 14. In general,  $t_{rv} + t_{fi} \approx t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (tc and tsv) which are guaranteed at 100°C.

Characteristic	Max	
Thermal Resistance Junction to Case		
Soldering Purposes: 1/8" From Cass for 5 Seconds		

3-1193



# Designers Data Sheet

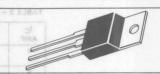
# SWITCHMODE SERIES NPN SILICON POWER TRANSISTORS

The MJE13008 and MJE13009 are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V switch-mode applications such as Switching Regulators, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

#### SPECIFICATION FEATURES:

- VCEO(sus) 400 V and 300 V
- Reverse Bias SOA with Inductive Loads @ T<sub>C</sub> = 100°C
- Inductive Switching Matrix 3 to 12 Amp, 25 and 100°C
   ...t<sub>C</sub> @ 8 A, 100°C is 120 ns (Typ).
- 700 V Blocking Capability
- SOA and Switching Applications Information.

# 12 AMPERE NPN SILICON POWER TRANSISTORS 300 and 400 VOLTS 100 WATTS



### Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

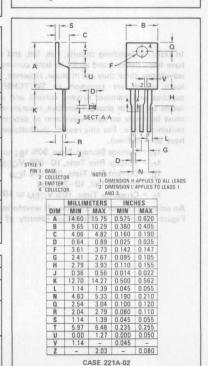
## MAXIMUM RATINGS

beniated eRating bits laviere	Symbol	MJE13008	MJE13009	Unit
Collector-Emitter Voltage	VCEO(sus)	300	400	Vdc
Collector-Emitter Voltage	VCEV	600	700	Vdc
Emitter Base Voltage	VEBO	MOUNT IS	9	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	12		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	2002 21 pn 12 lwa		Adc
Emitter Current — Continuous — Peak (1)	I <sub>E</sub>	18		Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	2 16 42		Watts mW/OC
Total Power Dissipation@T <sub>C</sub> = 25°C Derate above 25°C	PD	100		Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150		°C

# THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms. Duty Cycle ≤ 10%.

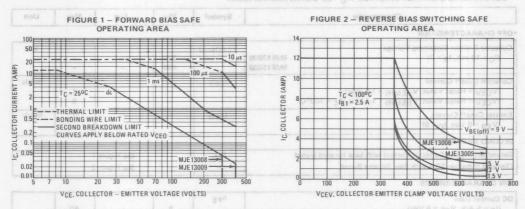


3-1194

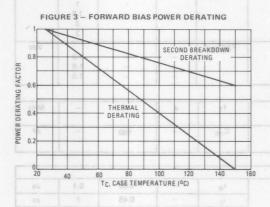
# ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted.)

OFF CHARACTERIS	OPERATING ASSA		_		Separate services	
	TICS		ABR	A DMITAREN	3	war new fift
Collector-Emitter Sus	taining Voltage	VCEO(sus)				Vdc
(I <sub>C</sub> = 10 mA, I <sub>B</sub> =			300			20
	MJE13009	1 2 2	400		1 - 1	11111
Collector Cutoff Curr		ICEV				mAd
	alue, V <sub>BE</sub> (off) = 1.5 Vdc)				5	2
	alue, V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)				3	
Emitter Cutoff Currer (VEB = 9 Vdc, IC		IEBO	HEDM	TIMIJ	any ara ang	mAd
A 0 - (Beliffix   15				- TIME IMAGES	ASRECTIONS BREAKING	12-
SECOND BREAKDO	TIN WILLIAM NOT		<b>HERLIE</b>	State of the	1011-12	the l
	ollector Current with base forward biased	IS/b.	SUN THE	See Figure		
Clamped Inductive SC	A with Base Reverse Biased	- 1mm 600	134 111	See Figure	2	0.2
ON CHARACTERIS	rics our une our our					
DC Current Gain	ADEA' OUTTEULD FULLER CTYML AD	hFE	301130A730	1 1/43 TING - BUT	A115 A115 304	
(IC = 5 Adc, VCE		s I bas i sarogi	8	ting Aros flguss	40	The
(IC = 8 Adc, VCE	= 5 Vdc)		6		30	
Collector-Emitter Satu	gration Voltage assimil own sis start	VCE(sat)			1	Vdc
(IC = 8 Adc, IB = 1	of a translator: average juncto(ch A d.)				1.5	
(IC = 12 Adc, IB =	3 Adc)	DINITA	MER DEN	SAIS GRAD	3	FIGURE
(IC = 8 Adc, IB = 1	1.6 Adc, T <sub>C</sub> = 100 <sup>o</sup> C)	ALTER OF	11-1		2	
Base-Emitter Saturation	n Voltage o edi medi nortenilarib ratisare	VBE(sat)	SECTION BY		177	Vdd
(IC = 5 Adc, IB =	1 Adc) and all a supply to steb ed?	- DRC	16130 -		1.2	1 183
(IC = 8 Adc, IB = 1	6 Ado Ta = 1000C)		The same of	-1-1-	1.6	-
E-100 10 100 100 100 100 100 100 100 100	A STATE OF THE STA				1	1
DYNAMIC CHARAC	TERISTICS 2025 S OT nerfly between					
DYNAMIC CHARAC Current-Gain — Bandv	TERISTICS OT MANY bolanes	f <sub>T</sub>	4	THEFT		MHz
Current-Gain — Bandv (I <sub>C</sub> = 500 mAdc, V	rERISTICS OT media believe		4	DERATING	-	MHz
Current-Gain — Bandv (I <sub>C</sub> = 500 mAdc, V	reristics  width Product  (CE = 10 Vdc, f = 1 MHz)	f <sub>T</sub>	4		-	MHz pF
OYNAMIC CHARAC Current-Gain — Bandw (I <sub>C</sub> = 500 mAdc, V Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub>	reristics width Product (CE = 10 Vdc, f = 1 MHz) = 0, f = 0.1 MHz)		4	DERATING	-	1 100
OYNAMIC CHARAC Current-Gain — Bandw (I <sub>C</sub> = 500 mAdc, V Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub>	reristics  width Product  (CE = 10 Vdc, f = 1 MHz)		4	DERATING	-	1 100
OVNAMIC CHARAC Current-Gain — Bandw (I <sub>C</sub> = 500 mAdc, V Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub> SWITCHING CHARA	reristics  width Product  CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz).  CTERISTICS		4	DERATING		1 100
DYNAMIC CHARAC' Current-Gain — Bandv (IC = 500 mAdc, \ Output Capacitance (VCB · 10 Vdc, IE SWITCHING CHARA Resistive Load (Table	reristics  width Product  CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz).  CTERISTICS		4 T	DERATING	-   -     -	1 100
DYNAMIC CHARAC  Current-Gain — Bandw (IC = 500 mAdc, V  Output Capacitance (VCB · 10 Vdc, IE  SWITCHING CHARA  Resistive Load (Table  Delay Time	vidth Product (CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz)  CTERISTICS  1)	C <sub>ob</sub>	1	180		pF
DYNAMIC CHARAC Current-Gain — Bandv (I <sub>C</sub> = 500 mAdc, V Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub>	VIOLET IN THE SECOND S	t <sub>d</sub> t <sub>r</sub> t <sub>e</sub>	087 00 (3°) 3RUT	180	0.1	pF
OYNAMIC CHARAC: Current-Gain — Bandw (I <sub>C</sub> = 500 mAdc, \\ Output Capacitance (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub> SWITCHING CHARA Resistive Load (Table Delay Time Rise Time	Vidth Product (CE = 10 Vdc, f = 1 MHz)  - 0, f = 0.1 MHz)  CTERISTICS  1)  (V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 8 A,  I <sub>B1</sub> = I <sub>B2</sub> = 1.6 A, τ <sub>p</sub> = 25 μs,	t <sub>d</sub> t <sub>r</sub> t <sub>e</sub>	087 00 (3°) 3RUT	0.06 0.45	0.1	pF μs μs
OYNAMIC CHARAC  Current-Gain — Bandw  (I <sub>C</sub> = 500 mAdc, \ Output Capacitance  (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub> SWITCHING CHARA  Resistive Load (Table  Delay Time  Storage Time  Fall Time	reristics  width Product (CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz).  CTERISTICS  1)  (VCC = 125 Vdc, I <sub>C</sub> = 8 A, I <sub>B1</sub> = I <sub>B2</sub> = 1.6 A, τ <sub>p</sub> = 25 μs, Duty Cycle ≤ 1%)	t <sub>d</sub> t <sub>r</sub> t <sub>s</sub>	087 00 (3°) 3RUT	0.06 0.45 1.3	0.1	pF μs μs μs
CUrrent-Gain — Bandw (IC = 500 mAdc, V Output Capacitance (VCB · 10 Vdc, IE SWITCHING CHARA Resistive Load (Table Delay Time Storage Time Fall Time	reristics  width Product (CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz)  CTERISTICS  1)  (VCC = 125 Vdc, I <sub>C</sub> = 8 A, I <sub>B1</sub> = I <sub>B2</sub> = 1.6 A, τ <sub>p</sub> = 25 μs, Duty Cycle ≤ 1%)  ped (Table 1, Figure 13)	Cob  td tr ts	087 00 (3°) 3RUT	0.06 0.45 1.3 0.2	0.1 1 3 0.7	pF μs μs μs μs
OVNAMIC CHARAC  Current-Gain — Bandw  (I <sub>C</sub> = 500 mAdc, V  Output Capacitance  (V <sub>CB</sub> · 10 Vdc, I <sub>E</sub> SWITCHING CHARA  Resistive Load (Table  Delay Time  Storage Time  Fall Time  Inductive Load, Clam	reristics  width Product (CE = 10 Vdc, f = 1 MHz)  = 0, f = 0.1 MHz).  CTERISTICS  1)  (VCC = 125 Vdc, I <sub>C</sub> = 8 A, I <sub>B1</sub> = I <sub>B2</sub> = 1.6 A, τ <sub>p</sub> = 25 μs, Duty Cycle ≤ 1%)	t <sub>d</sub> t <sub>r</sub> t <sub>s</sub>	087 00 (3°) 3RUT	0.06 0.45 1.3	0.1	pF μs μs μs





The Safe Operating Area figures shown in Figures 1 and 2 are specified ratings for these devices under the test conditions shown.

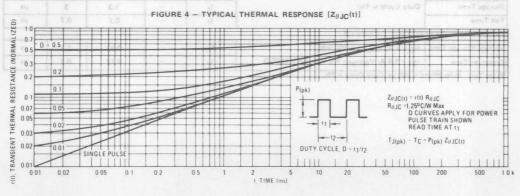


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

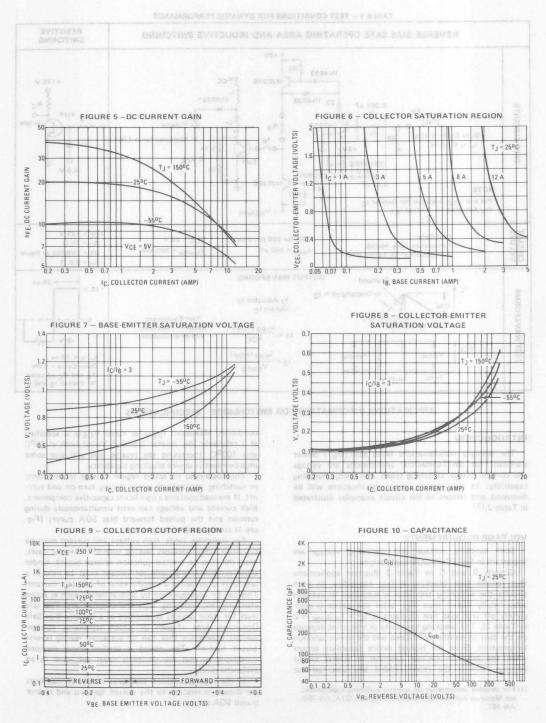
The data of Figure 1 is based on  $T_C=25^{\circ}C$ ,  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 1 may be found at any case temperature by using the appropriate curve on Figure 3.

 $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

Use of reverse biased safe operating area data (Figure 2) is discussed in the applications information section.







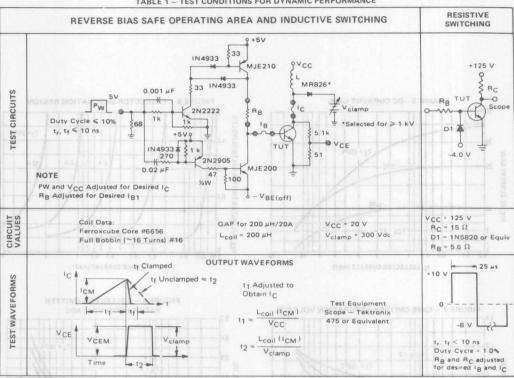


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

# APPLICATIONS INFORMATION FOR SWITCHMODE SPECIFICATIONS

# INTRODUCTION

The primary considerations when selecting a power transistor for SWITCHMODE applications are voltage and current ratings, switching speed, and energy handling capability. In this section, these specifications will be discussed and related to the circuit examples illustrated in Table 2.(1)

# **VOLTAGE REQUIREMENTS**

Both blocking voltage and sustaining voltage are important in SWITCHMODE applications.

Circuits B and C in Table 2 illustrate applications that require high blocking voltage capability. In both circuits the switching transistor is subjected to voltages substantially higher than  $V_{CC}$  after the device is completely off (see load line diagrams at  $I_{C}=I_{leakage}\approx 0$  in Table 2). The blocking capability at this point depends on the base to emitter conditions and the device junction temperature. Since the highest device capability occurs when the base to emitter junction is reverse biased (VCEV), this is the recommended and specified use

condition. Maximum I<sub>CEV</sub> at rated V<sub>CEV</sub> is specified at a relatively low reverse bias (1.5 Volts) both at 25°C and 100°C. Increasing the reverse bias will give some improvement in device blocking capability.

The sustaining or active region voltage requirements in switching applications occur during turn-on and turn-off. If the load contains a significant capacitive component, high current and voltage can exist simultaneously during turn-on and the pulsed forward bias SOA curves (Figure 1) are the proper design limits.

For inductive loads, high voltage and current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as a Reverse Bias Safe Operating Area (Figure 2) which represents voltage-current conditions that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

In the four application examples (Table 2) load lines are shown in relation to the pulsed forward and reverse biased SOA curves.

For detailed information on specific switching applications, see Motorola Application Notes An-719, AN-737A, AN-752, AN-767.

#### **VOLTAGE REQUIREMENTS** (continued)

In circuits A and D, inductive reactance is clamped by the diodes shown. In circuits B and C the voltage is clamped by the output rectifiers, however, the voltage induced in the primary leakage inductance is not clamped by these diodes and could be large enough to destroy the device. A snubber network or an additional clamp may be required to keep the turn-off load line within the Reverse Bias SOA curve.

Load lines that fall within the pulsed forward biased SOA curve during turn-on and within the reverse bias SOA curve during turn-off are considered safe, with the following assumptions:

- (1) The device thermal limitations are not exceeded.
- (2) The turn-on time does not exceed 10 µs (see standard pulsed forward SOA curves in Figure 1).
- (3) The base drive conditions are within the specified limits shown on the Reverse Bias SOA curve (Figure 2).

#### **CURRENT REQUIREMENTS**

An efficient switching transistor must operate at the required current level with good fall time, high energy

handling capability and low saturation voltage. On this data sheet, these parameters have been specified at 8 amperes which represents typical design conditions for these devices. The current drive requirements are usually dictated by the VCE(sat) specification because the maximum saturation voltage is specified at a forced gain condition which must be duplicated or exceeded in the application to control the saturation voltage.

#### SWITCHING REQUIREMENTS

In many switching applications, a major portion of the transistor power dissipation occurs during the fall time (tfi). For this reason considerable effort is usually devoted to reducing the fall time. The recommended way to accomplish this is to reverse bias the base-emitter junction during turn-off. The reverse biased switching characteristics for inductive loads are discussed in Figure 11 and Table 3 and resistive loads in Figures 13 and 14. Usually the inductive load component will be the dominant factor in SWITCHMODE applications and the inductive switching data will more closely represent the device performance in actual application. The inductive switching characteristics are derived from the same circuit used to specify the reverse biased SOA curves, (See Table 1) providing correlation between test procedures and actual use conditions.

# RESISTIVE SWITCHING PERFORMANCE

FIGURE 11 - TURN-ON TIME

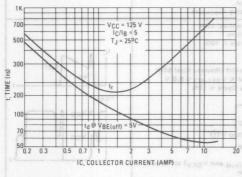


FIGURE 13 - INDUCTIVE SWITCHING MEASUREMENTS

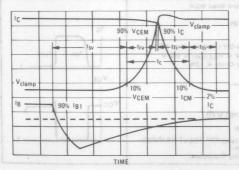


FIGURE 12 - TURN-OFF TIME

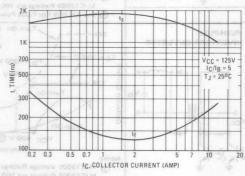
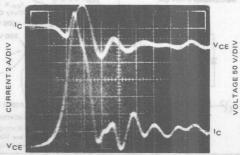


FIGURE 14 – TYPICAL INDUCTIVE SWITCHING WAVEFORMS
(at 300 V and 12 A with I<sub>B1</sub> = 2.4 A and V<sub>BE(off)</sub> = 5 V)



TIME 20 ns/DIV



TABLE 2 - APPLICATIONS EXAMPLES OF SWITCHING CIRCUITS TIME DIAGRAMS CIRCUIT LOAD LINE DIAGRAMS SERIES SWITCHING Turn-On (Forward Bias) SOA REGULATOR ton ≤ 10 µs Duty Cycle ≤ 10% TC = 100°C PD = 4000 W (2) 350 V Turn-Off (Reverse Bias) SOA 12A-Turn-On 1.5 V ≤ VBE(off) ≤ 9.0 V Duty Cycle ≤ 10% Vcc Vo Vcc VCC 400 V 1 Collector Voltage 1 MJE13009 Voltage Ratings (VCEO(sus) and VCEV) are shown, MJE 13008 Ratings are 100 V Lower.
(2) See AN-569 for Pulse Power Derating Procedure. Turn-On (Forward Bias) SOA RINGING CHOKE t<sub>on</sub> ≤ 10 μs Duty Cycle ≤ 10% INVERTER = 4000 W (2) Vo Vcc Turn-Off (Reverse Bias) SOA 1.5 V ≤ VBE(off) ≤ 9.0 V Nº Duty Cycle ≤ 10% Leakage Spike Turn-On VCC + N(Vo) Vcc 400 V ① Spike 700 V ① + vcc VCC + N(Vo) Collector Voltage VCC Notes ① MJE13009 Voltage Ratings (VCEO(sus) and VCEV) are shown, MJE13008 Ratings are 100 V Lower 2 See AN-569 For Pulse Power Derating Procedure Turn-On (Forward Bias) SOA PUSH-PULL t<sub>on</sub> ≤ 10 µs INVERTER/CONVERTER Duty Cycle ≤ 10%  $T_{C} = 100^{\circ}C$ PD = 4000 W (2) Turn-Off (Reverse Bias) SOA 1.5 V ≤ V<sub>BE(off)</sub> ≤ 9.0 V Turn-On Duty Cycle ≤ 10% tor VCE C 2 VCC Turn-Of 700 V ① VCC 400 V 1 VCC Collector Voltage Notes ① MJE13009 Voltage Ratings (V<sub>CEO(sus)</sub> and V<sub>CEV</sub>) are shown, MJE13008 Ratings are 100 V Lower. 2 See AN-569 for Pulse Power Derating Procedure. Turn-On (Forward Bias) SOA SOLENOID DRIVER t<sub>on</sub> ≤ 10 µs Duty Cycle ≤ 10% = 4000 W (2) TC = 100°C Turn-Off (Reverse Bias) SOA Vcc 1.5 V ≤ VBE(off) ≤ 9.0 V toff 12A CC Solenoid D VCE Turn-Off Col Turn-On Vcc VCC 400 V 1 700 V (1) Collector Voltage Notes

1 MJE13009 Voltage Ratings (VCEO(sus) and VCEV) are shown,

MJE13008 Ratings are 100 V Lower.

② See AN-569 for Pulse Power Derating Procedure.

#### TABLE 3 - TYPICAL INDUCTIVE SWITCHING PERFORMANCE

5 AMPERE	I <sub>C</sub>	T <sub>C</sub> °C	t <sub>sv</sub>	t <sub>rv</sub>	t <sub>fi</sub>	t <sub>ti</sub>	t <sub>c</sub>
	3	25	770	100	150	200	240
NEM SITICON		100	1000	230	160	200	320
PER TRANSIST	5	25	630	72	26	10	100
400 AND 460 VOLT		100	820	100	55	30	180
	8	25	720	55	27	2	77
		100	920	70	50	8	120
	12	25	640	20	17	2	41
		100	800	32	24	4	54

NOTE: All Data recorded in the inductive Switching Circuit in Table 1.

### SWITCHING TIME NOTES

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>CEM</sub>

try = Voltage Rise Time, 10-90% VCEM

tfi = Current Fall Time, 90-10% ICM

tti = Current Tail, 10-2% ICM

t<sub>C</sub> = Crossover Time, 10% V<sub>CEM</sub> to 10% I<sub>CM</sub>

An enlarged portion of the turn-off waveforms is shown in Figure 13 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

Switching Regulators

Sotenoid and Relay Drivers

⊕ Inverters

PSWT = 1/2 VCCIC(tc) f

Typical inductive switching waveforms are shown in Figure 14. In general,  $t_{rv} + t_{fi} \cong t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_{\text{C}}$  and  $t_{\text{SV}}$ ) which are guaranteed at  $100^{\circ}\text{C}$ .

Characteristic	Symbol	Mus	Unit
Thermal Resistance, Junction to Case	Rauc	1.56	°C/W
Maximum Lead Temperarure Tot Soldering	Tr.	275	°C
Purposes Tref from Case for 6 Seconds	105	107	
The Police Test	Pulse Wattr	6 no. Outy Cycle	105

CASE 221A-C TO-220AB

3-1201



# Designer's Data Sheet

# SWITCHMODE II SERIES NPN SILICON POWER TRANSISTORS

The MJE13070 and MJE13071 transistors are designed for highvoltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls, Isopinion at specify yer
- Deflection Circuits

Fast Turn-Off Times

100 ns Inductive Fall Time @ 25°C (Typ) 150 ns Inductive Crossover Time @ 25°C (Typ)

400 ns Inductive Crossover Time @ 25°C (Typ)

#### Operating Temperature Range -65 to +150°C

100°C Performance Specified for:
Reverse-Biased SOA with Inductive Loads
Switching Times with Inductive Loads
Saturation Voltages

Leakage Currents

# MAXIMUM RATINGS

Rating	Symbol	MJE13070	MJE13071	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	400	450	Vdc
Collector-Emitter Voltage	VCEV	650	750	Vdc
Emitter Base Voltage	VEB	6	.0	Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub>	5.0 8.0		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	2.0 4.0		Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C @ T <sub>C</sub> = 100°C Derate above 25°C	PD	80 32 0.64		Watts
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.56	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

#### 5 AMPERE

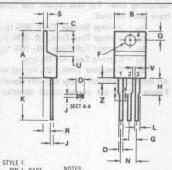
# NPN SILICON POWER TRANSISTORS

400 AND 450 VOLTS 80 WATTS



#### Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data representing device characteristics boundaries — are given to facilitate "worst case" design.



PIN 1. BASE NOT 2. COLLECTOR 1 3. EMITTER 4 4. COLLECTOR

NOTES:

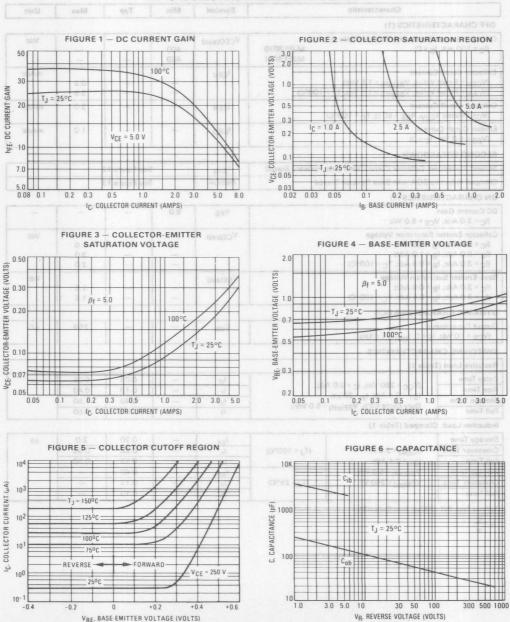
1. DIMENSION H APPLIES TO ALL LEADS.
2. DIMENSION L APPLIES TO LEADS 1
AND 3

	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

CASE 221A-02 TO-220AB

	Characteristic		Symbol	Min	Тур	Max	Unit	
OFF CHARACTE	ERISTICS (1)							
Collector-Emitter	Sustaining Voltage (Table 1)	PIGURI	V <sub>CEO(sus)</sub>	ENT GATE	- ос сикв	FIGURET	Vdc	
(I <sub>C</sub> = 100 mA, I <sub>E</sub>	3 = 0)	MJE13070	FT TO TO	400	PERTIT		50171	
		MJE13071		450				
Collector Cutoff C			ICEV				mAdc	
	/alue, VBE(off) = 1.5 Vdc)	10000		7/	HTLL	0.5 2.5	100	
	Value, VBE(off) = 1.5 Vdc, TC =			1		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	- 1	
Collector Cutoff C (VCE = Rated V	urrent CEV, RBE = 50 $\Omega$ , T <sub>C</sub> = 100°C)	0.0 8	ICER		HITH	3.0	mAdc	
(V <sub>EB</sub> = 6.0 Vdc,		8 02 C=	IEBO	Ť	V 0.8 = 33V	1.0	mAdc	
SECOND BREAK	KDOWN	10 E	77					
Second Breakdow	n Collector Current with Base	e Forward Biased	Is/b		See Figure 12	2		
Clamped Inductiv	e SOA with Base Reverse Bia	sed	RBSOA	-	See Figure 1:	3		
		EUG 19.0	08 06 0	2.0 1	01 80	68 5.9	1.6 80.8	
ON CHARACTE	110 110 5 (1)			0.0	125 W. D. COTO SA	60 3		
DC Current Gain (I <sub>C</sub> = 3.0 Adc, V	CE = 5.0 Vdc		hFE	8.0	_			
	Saturation Voltage		VCE(sat)	ETTIMB N	отовшоо -	FIGURE 3	Vdc	
	= 0.6 Adc) 32A6 - 33AU2			TAGE	RATION VOL			
(Ic = 5.0 Adc, Ig	= 1.0 Adc) = 0.6 Adc, T <sub>C</sub> = 100°C)			7211		3.0 2.0	LLL Jos	
Base-Emitter Sati		HH a	V <sub>BE(sat)</sub>			2.0	Vdc	
(IC = 3.0 Adc, IE						1.5	11110	
(IC = 3.0 Adc, IE	= 0.6 Adc, T <sub>C</sub> = 100°C)	111111111111111111111111111111111111111		- 11	- 0	1.5		
DYNAMIC CHAI	RACTERISTICS		1	nener I				
Output Capacitan (V <sub>CB</sub> = 10 Vdc,	ce  E = 0, f <sub>test</sub> = 1.0 kHz)		C <sub>ob</sub>	3-11		250	pF	
SWITCHING CH	ARACTERISTICS		0.05-1				01	
Resistive Load (T	able 1)	10						
Delay Time		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	T		0.03	0.05	10	
Rise Time	(V <sub>CC</sub> = 250 Vdc, I <sub>C</sub> = 3.0 A	Adc,	t <sub>d</sub>		0.03	0.40	μS	
Storage Time	$I_{B1} = 0.4 \text{ Adc}, t_p = 30 \mu s,$	000.0	us t <sub>s</sub> ac a	1.0 — 2	0.40	1.50	0.05	
Fall Time	Duty Cycle ≤2%, VBE(off)	= 5.0 Vdc)	tf	(24MA) (	0.175	0.50		
Inductive Load, C	Clamped (Table 1)							
Storage Time			t <sub>sv</sub>	THE P	0.70	2.0	μs	
Crossover Time	(I <sub>C(pk)</sub> = 3.0 A,	(T <sub>.1</sub> = 100°C)	t <sub>C</sub>	n Tioru	0.28	0.50	PIR MS	
Fall Time	I <sub>B1</sub> = 0.4 Adc,	-1-1-1 xn1	tfi	-	0.15	0.30	1	
Storage Time	VBE(off) = 5.0 Vdc,		t <sub>sv</sub>	1	0.40			
Crossover Time	V <sub>CE(pk)</sub> = 250 V)	(T <sub>J</sub> = 25°C)	t <sub>c</sub>	C F V	0.15		1	
Fall Time			tfi	Y	0.10		For	
	300 μs. Duty Cycle ≤2%.	non I		1		7		
$\beta_f = \frac{I_C}{I_B}$								
IB IB					-			
					AMROT	- BERSYTH		

# TYPICAL ELECTRICAL CHARACTERISTICS TEMPSTOAMAND JADIATOSAS



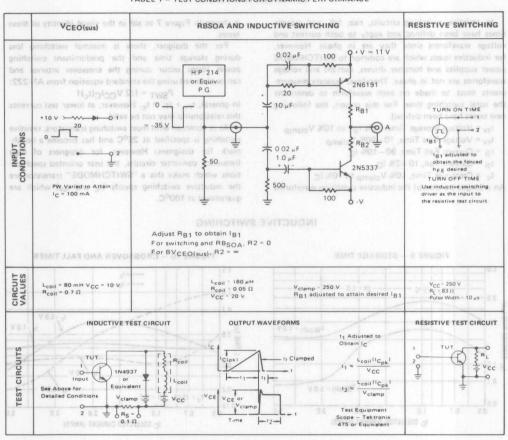
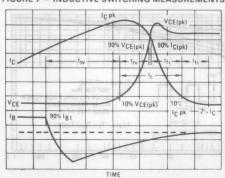
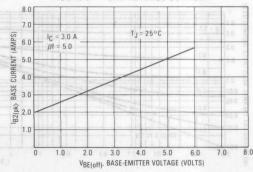


TABLE 1 - TEST CONDITIONS FOR DYNAMIC PERFORMANCE

# FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS JAMASH — IT FIGURE 8 — PEAK REVERSE CURRENT





# SWITCHING TIMES NOTE TEST - 1 3 JEAT

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t<sub>sv</sub> = Voltage Storage Time, 90% I<sub>B1</sub> to 10% V<sub>clamp</sub>

try = Voltage Rise Time, 10-90% Vclamp

tfi = Current Fall Time, 90-10% IC

tti = Current Tail, 10-2% IC

t<sub>C</sub> = Crossover Time, 10% V<sub>clamp</sub> to 10% I<sub>C</sub>

An enlarged portion of the inductive switching waveforms

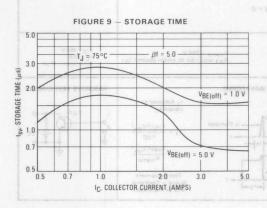
In resistive switching circuits, rise, fall, and storage is shown in Figure 7 to aid in the visual identity of these mes have been defined and apply to both current and terms.

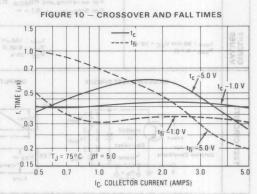
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

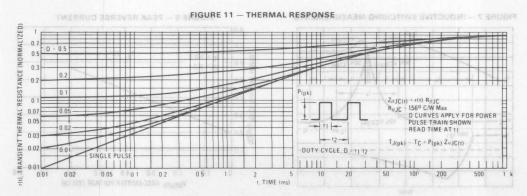
 $P_{SWT} = 1/2 \ V_{CC} I_{C}(t_{c}) f$  In general,  $t_{rv} + t_{fi} \simeq t_{c}$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}\text{C}$  and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds  $\{t_{\text{C}} \text{ and } t_{\text{SV}}\}$  which are guaranteed at  $100^{\circ}\text{C}$ .

# INDUCTIVE SWITCHING

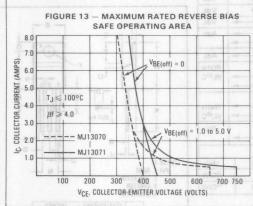












# SAFE OPERATING AREA INFORMATION

#### FORWARD BIAS

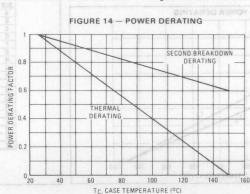
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 12 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

 $T_{J(pk)}$  may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 13 gives RBSOA characteristics.





# COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTORS**

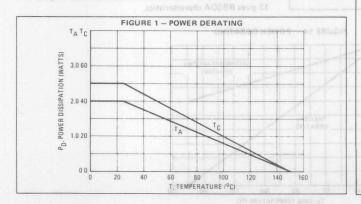
- . . . designed for use as high-frequency drivers in audio amplifiers.
- DC Current Gain Specified to 4.0 Amperes
- hFE = 40(Min) @ IC = 3.0 Adc = 20(Min) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage —

VCEO(sus) = 120 Vdc (Min) - MJE15028, MJE15029 (Mg)LT 3000 = OT a = 150 Vdc (Min) - MJE15030, MJE15031

- High Current Gain Bandwidth Product ed taum of T = 30 MHz (Min) @ IC = 500 mAdc
- TO-220AB Compact Package
- TO-66 Leadform Also Available

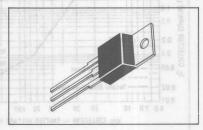
MAXIMUM RATINGS				
Rating lating	Symbol	MJE15028 MJE15029	MJE15030 MJE15031	Unit
Collector-Emitter Voltage	VCEO	120	150	Vdc
Collector-Base Voltage	VCB	120	150	Vdc
Emitter-Base Voltage	VEB	-5	.0 — 0.	Vdc
Collector Current — Continuous — Peak	IC	8.0		Adc
Base Current	IB	2.0		Adc
Total Power Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	P <sub>D</sub>	50		Watts W/OC
Total Power Dissipation  © T <sub>A</sub> = 25°C  Derate above 25°C	PD 9	2,0		Watts W/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150		°C

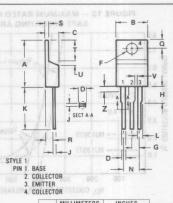
THERMAL CHARACTERISTICS						
Characteristic	Symbol	Max	Unit			
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	°C/W			
Thermal Resistance, Junction to Ambient	$R_{\theta}JA$	62.5	°C/W			



# 8 AMPERE 30 Mail and **POWER TRANSISTORS** COMPLEMENTARY SILICON

120-150 VOLTS 50 WATTS





	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.14	-	0.045	-
Z	-	2.03	-	0.080

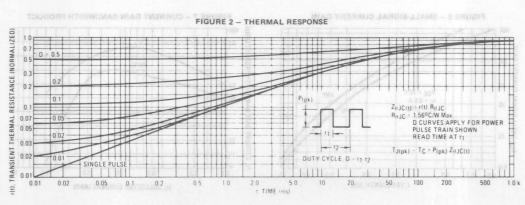
FIGURE 3 - FORWARD BIAS

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				01
Collector-Emitter Sustaining Voltage (M).  (IC = 10 mAdc, IB = 0)  MJE15028, MJE15029  MJE15030, MJE15031	VCEO(sus)	120 150		Vdc
Collector Cutoff Current  (VCE = 120 Vdc, I <sub>B</sub> = 0)  (VCE = 150 Vdc, I <sub>B</sub> = 0)  MJE15028, MJE15029  (VCE = 150 Vdc, I <sub>B</sub> = 0)  MJE15030, MJE15031	ICEO	8502) SkM	0.1 0.1	II manager
Collector Cutoff Current (V <sub>CB</sub> = 120 Vdc, I <sub>E</sub> = 0) MJE15028, MJE15029 (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) MJE15030, MJE15031	ГСВО	REDAT FLM	10 10	μAdc
	120 150	20 90	01 0.6	
Emitter Cutoff Current (V <sub>BE</sub> $\frac{\pi}{2}$ 5.0 Vdc, I <sub>C</sub> = 0)	IEBO	2001224 03,10	10	μAdc
ON CHARACTERISTICS (1)		COLORADO BACO	20074400 6 20	*11000
DC Current Gain $(I_C = 0.1 \text{ Adc}, V_{CE}^2 = 2.0 \text{ Vdc})$	pEE	40	TARBO BRAZ	
(I <sub>C</sub> = 0.0 Adc, V <sub>CE</sub> = 2.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 2.0 Vdc)		40 40		
(IC = 4.0 Adc, VCE = 2.0 Vdc)		20	- // //	

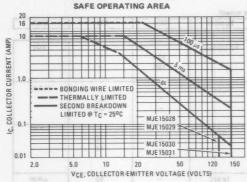
DC Current Gain $(I_C = 0.1 \text{ Adc}, V_{CE}^* = 2.0 \text{ Vdc})$		pŁE	40 A D M	SAPE OPERA	-
(IC = 2.0 Adc, VCE = 2.0 Vdc)			40	1 -1 7	0.0
(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 2.0 Vdc)			40	- 0	
(I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	005		20	- 1/11	
DC Current Gain Linearity (VCE From 2.0V to 20V, IC From 0.1A to 3A)		hFE	Typ 2	1/11	
(NPN TO PNP)	007		3	4/11	0f = g(\ 5)
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	02 AV	VCE(sat)	many 1	0.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 2.0 Vdc)	DE 40	VBE(on)	Type	1.0	Vdc os
DYNAMIC CHARACTERISTICS			Vaclor V		0.1
Current Gain - Bandwidth Product (2)	01	fT	30		MHz
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 10 MHz)			140 150		ear e
ANY LOUIS DOLLY LEVY WARRY AND A		127.70	STATE VIEW TO ASSESSED	R. R G T T R T T R T T T T T T T T T	

<sup>(1)</sup>Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

<sup>(2)</sup> f T = | hfe | • ftest



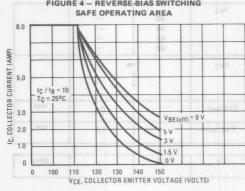




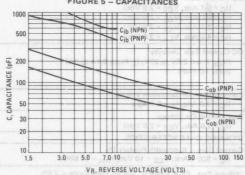
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC - VCE limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 3 and 4 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 150^{\circ} C$ .  $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

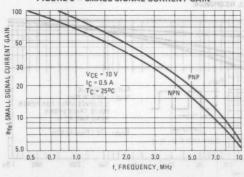
# FIGURE 4 - REVERSE-BIAS SWITCHING



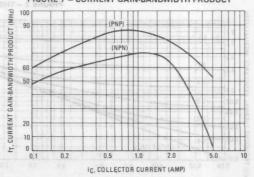
# FIGURE 5 - CAPACITANCES

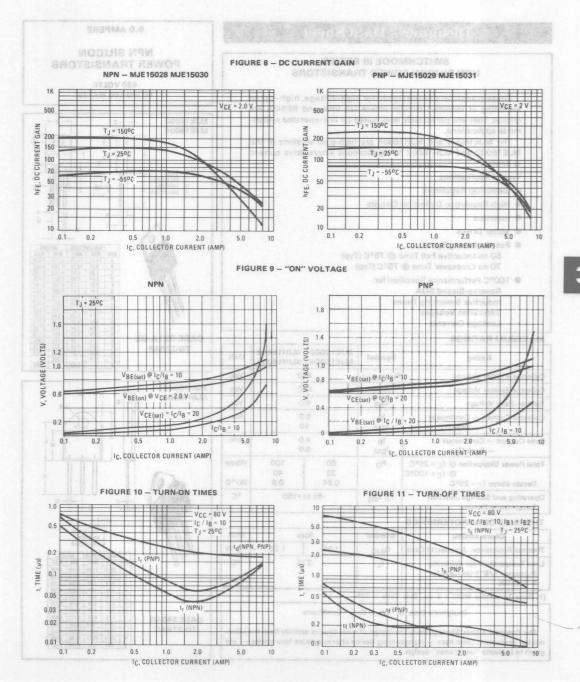


# FIGURE 6 - SMALL-SIGNAL CURRENT GAIN



# FIGURE 7 - CURRENT GAIN-BANDWIDTH PRODUCT







# Designer's Data Sheet

# SWITCHMODE III SERIES NPN SILICON POWER TRANSISTORS

These transistors are designed for high-voltage, high-speed switching of inductive circuits where fall time and RBSOA are critical. They are particularly well-suited for line-operated switch-mode applications.

The MJE16004 and MJH16004 are high-gain versions of the MJE16002 and MJH16002 for applications where drive current is limited.

Typical Applications:

- Switching Regulators
- High Resolution Deflection Circuits
- Inverters
- Motor Drives
- Fast Switching Speeds
   50 ns Inductive Fall Time @ 75°C (Typ)
   70 ns Crossover Time @ 75°C (Typ)
- 100°C Performance Specified for: Reverse-Biased SOA Inductive Switching Times Saturation Voltages Leakage Currents

# MAXIMUM RATINGS

Rating	Symbol	MJE16002 MJE16004	MJH16002 MJH16004	Unit
Collector-Emitter Voltage	V <sub>CEO(sus)</sub>	450		Vdc
Collector-Emitter Voltage	VCEV	850		Vdc
Emitter-Base Voltage	VEB	6.0		Vdc
Collector Current — Continuous — Peak (1)	I <sub>C</sub> M	5.0 10		Adc
Base Current — Continuous — Peak (1)	I <sub>B</sub>	4.0 8.0		Adc
Total Power Dissipation @ $T_C = 25^{\circ}C$ @ $T_C = 100^{\circ}C$ Derate above $T_C = 25^{\circ}C$	PD	80 100 32 40 0.64 0.8		Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150		°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	M	Unit	
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.56	1.25	°C/W
Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	TL	275		°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

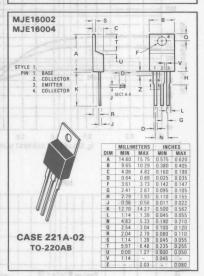
Designer's Data for "Worst Case" Conditions

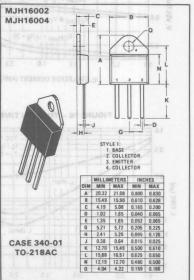
The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

#### 5.0 AMPERE

# NPN SILICON POWER TRANSISTORS

450 VOLTS 80 and 100 WATTS





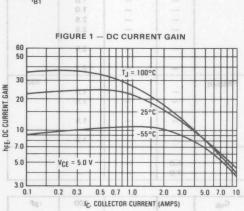
	Character	stic		Symbol	Min	Тур	Max	Unit
OFF CHARACTER	ISTICS (1)			5008	2111.881.50	0013186	od (Table 2)	ductive Lo
Collector-Emitter Si		(Table 2)	val .	V <sub>CEO(sus)</sub>	450	_	1 + 6	Vdc
(IC = 100 mA, IB =				(3900) =	m		30	amil'i lis
Collector Cutoff Cur	rent 051	- 1	07	ICEV		= Q.4-Aule;	egi am	mAdc
(VCEV = 850 Vdc,		c)		CLV	-	som -5.0 veg	0.25	ornge Firm
(VCEV = 850 Vdc,	VBE(off) = 1.5 Vd	c, T <sub>C</sub> = 100°C)		= 150°C1	(I) - (I	5V-005-1/g()	JV 1.5	amil ti
Collector Cutoff Cur	rent	-	pl l	ICER	_		2.5	mAdc
(VCE = 850 Vdc, F	BE = 50 Ω, T <sub>C</sub> = 1	00°C)		\$00t	PHUM: NO		S eldeT) be	ductive L
Emitter Cutoff Curre	ent		vz1	IEBO	-	_	1.0	mAdc
(VEB = 6.0 Vdc, Ic	= 0)			100001 =	m		all line	expiT ily
SECOND BREAKE	OOWN		al al			= 0.3 Adc.	raf lan	rossovar Ti
		with Base Foru	ward Riased	BNV OWNERS AND SHOW A SHIP BROWN				
Second Breakdown Collector Current with Base Forward Biased Clamped Inductive SOA with Base Reverse Biased			vara Diasco	IS/b RBSOA	(3) 1 (	20 000 - 1000	gure 19	emi7 Ib
		everse biaseu	- 1	NBSOA		366 11	gure 13	I tevosaci
ON CHARACTERI	STICS (1)					Dury Cycle 42%	PW - 300 µs.	Polos Test:
Collector-Emitter Sa				V <sub>CE(sat)</sub>				Vdc
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> =		MJE16002/M			-	-	1.0	rei
(I <sub>C</sub> = 1.5 Adc, I <sub>B</sub> =		MJE16004/M			-		1.0	13-18
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> =		MJE16002/M MJE16004/M			-		2.5	
$(I_C = 3.0 \text{ Adc}, I_B = (I_C = 3.0 \text{ Adc}, I_B = 0.0 \text{ Adc})$		WJE 160047 W	3110004		MADY	HERMUD DU	- Panuoi	
T <sub>C</sub> = 100°C)	0.4 Auc,	MJE16002/M	JH16002				2.5	
(IC = 3.0 Adc, IB =	0.3 Adc.				-			
T <sub>C</sub> = 100°C)		MJE16004/M	JH16004		-	20001 - 77	2.5	
Base-Emitter Satur	ation Voltage	一日日出	0.1 50	V <sub>BE(sat)</sub>		TINT		Vdc
(IC = 3.0 Adc, IB =		MJE16002/M	JH16002	DE(GGC)	- 1		1.5	-
(IC = 3.0 Adc, IB =	0.3 Adc)	MJE16004/M	JH16004		1-18	7 1	1.5	111
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> =	0.4 Adc,				100		-	1
T <sub>C</sub> = 100°C)	0244	MJE16002/M	JH16002		100	1	1.5	
(I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = T <sub>C</sub> = 100°C)	U.3 Adc,	MJE16004/M	LIH16004	HI LZ		71.55 H.H.H.	1.5	100
DC Current Gain	$\pm \prime \prime \pm \prime \pm$	11021000771		hee				
(Ic = 5.0 Adc, Vc	= 5 0 Vdc)	MJE16002/N	LIH16002	hFE	5.0		4- V 0.2 = 00	
(1) 0.0 7.00, 40	0.0 (00)	MJE16004/N		MILLI-	7.0		-	1
DYNAMIC CHARA	CTEDISTICS							
62 19 19	CO LU 31	1.0. 10.0 80.0	0.00	S.C. 2.B. 1B.	28 38	0.1 7.0	20 60 5	0 1.0
Output Capacitance				Cob	( <del>0</del> 1/03)	TESTING - ROTOS	200	pF
(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub>	= 0, T <sub>test</sub> = 1.0 KF	12)						
SWITCHING CHA	RACTERISTICS							
Resistive Load (Tal	ole 1) MJE16	002/MJH160	02					
Delay Time	112044	TITI	700	t <sub>d</sub>	1- 1	30	100	ns
Rise Time	(I <sub>C</sub> = 3.0 Adc,	(I <sub>B2</sub> =	0.8 Adc,	tr		100	300	
Storage Time	V <sub>CC</sub> = 250 Vdc, I <sub>B1</sub> = 0.4 Adc,	R <sub>B2</sub> =	8.0 n)	ts		1000	3000	
Fall Time	PW = 30 μs,		5	tf		60	300	
Storage Time	Pvv = 30 μs, Duty Cycle ≤2.0	2%) (Var.	off) = 5.0 Vdc)	ts		400		
Fall Time	Duty Gyole 42.	(ARE(	on) - 0.0 vac)	tf		130		
Resistive Load (Tal	ole 1) MJE16	004/MJH160	04				U = 01 :	19 1
Delay Time	112011	The transfer of	- 100 pt 1	td	N- H	30	100	ns
Rise Time	(I <sub>C</sub> = 3.0 Adc,	(lg2 =	0.6 Adc,	tr		130	300	
Storage Time	V <sub>CC</sub> = 250 Vdc,		8.0 n)	ts	-10-2	800	2700	
Fall Time	I <sub>B1</sub> = 0.3 Adc,		1 %	t <sub>f</sub>	= 11	80	350	1
Storage Time	PW = 30 μs,	2001		ts	-	250		
Fall Time	Duty Cycle ≤2.0	1%)   (VRE	off) = 5.0 Vdc)	tf	-	60		Training .

## SWITCHING CHARACTERISTICS (continued) [Define asternative seeing 0°22 a 57] BOIT STREET ARAKO JACISTOSJE

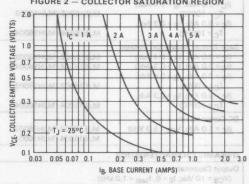
	Characteristics		Symbol	Min	Тур	Max	Unit
Inductive Load (T	able 2) MJE16002/	MJH16002			(1) (	CTERISTICS	OFF CHARA
Storage Time	1	VCEO(eus) 45	tsv	( <del>C</del> eld)	500	1600	na na lie
Fall Time	(I <sub>C</sub> = 3.0 Adc,	(T <sub>J</sub> = 100°C)	tfi	-	100	200	1001 = 30
Crossover Time	I <sub>B1</sub> = 0.4 Adc,	scant	tc	-	120	250	Collector Cur
Storage Time	VBE(off) = 5.0 Vdc,	-	t <sub>sv</sub>	-	600	O Vites Vinsola	(Very = 88
Fall Time	VCE(pk) = 400 Vdc)	(T <sub>J</sub> = 150°C)	tfi	D°00# = 3	120	O VIEW VBEN	(VCEV = 88
Crossover Time	2	830	t <sub>c</sub>	_	160	off Current	u) ramello
Inductive Load (T	able 2) MJE16004/	MJH16004		(D)*	0 n, Tc = 100	Vdc, Rgg = 8	(ACE = 820)
Storage Time		0831	tsv	_	400	1300	ns
Fall Time	(Ic = 3.0 Adc,	(T <sub>J</sub> = 100°C)	tfi	_	80	150	0.8 = 83A)
Crossover Time	I <sub>B1</sub> = 0.3 Adc,		t <sub>c</sub>	-	90	200	в омора
Storage Time	VBE(off) = 5.0 Vdc,		tsv		450	wallon Family	or (8 broom)
Fall Time	VCE(pk) = 400 Vdc)	(T <sub>J</sub> = 150°C)	tfi	-	100		
Crossover Time	Saé Pigure 19	AOSBR	t <sub>c</sub>	750 <u>B</u> 18980	110	NY AUG SYNO	lumped Inc.

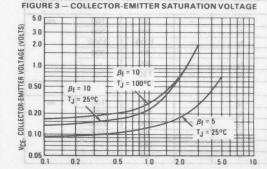






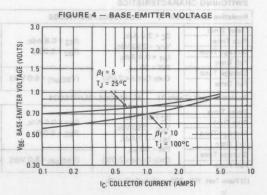
#### FIGURE 2 — COLLECTOR SATURATION REGION



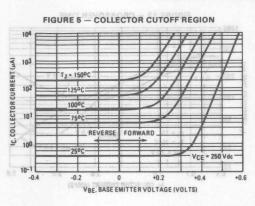


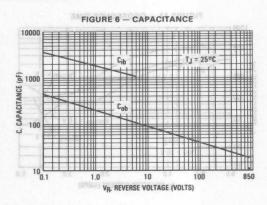
IC. COLLECTOR CURRENT (AMPS)

0.2

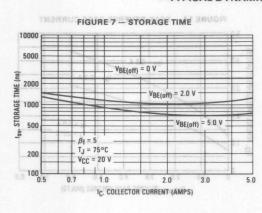


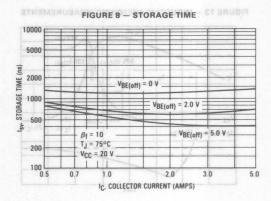
#### TYPICAL STATIC CHARACTERISTICS (continued)

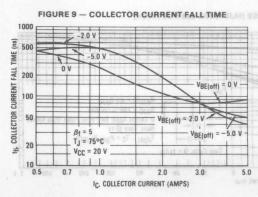


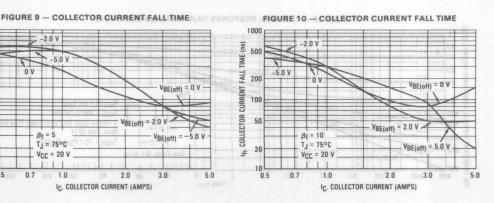


#### TYPICAL DYNAMIC CHARACTERISTICS

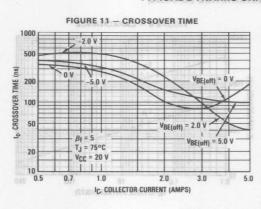


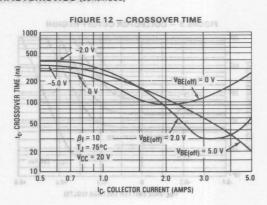






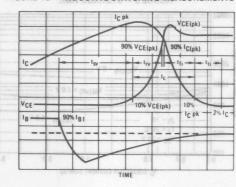
#### TYPICAL DYNAMIC CHARACTERISTICS (continued)



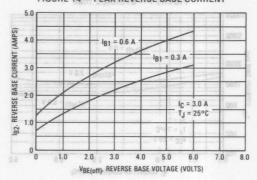


#### TYPICAL ELECTRICAL CHARACTERISTICS

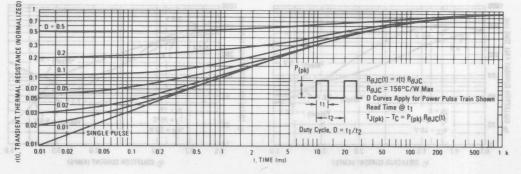
FIGURE 13 — INDUCTIVE SWITCHING MEASUREMENTS



#### FIGURE 14 — PEAK REVERSE BASE CURRENT

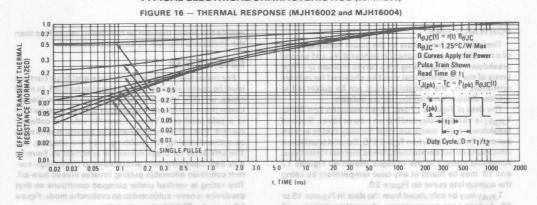






## 3

#### TYPICAL ELECTRICAL CHARACTERISTICS (continued)



#### SAFE OPERATING AREA INFORMATION

FIGURE 17 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA (MJE16002 and MJE16004)

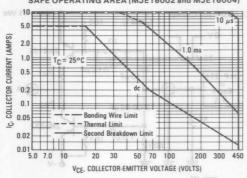


FIGURE 19 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA

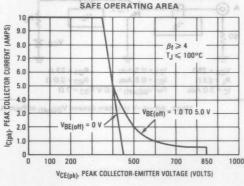


FIGURE 18 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA (MJH16002 and MJH16004)

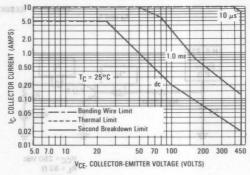
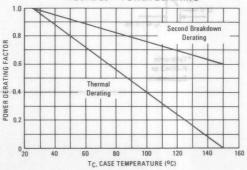


FIGURE 20 - POWER DERATING



#### SAFE OPERATING AREA INFORMATION

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 17 and 18 are based on Tc = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 17 and 18 may be found at any case temperature by using the appropriate curve on Figure 20.

T<sub>J(pk)</sub> may be calculated from the data in Figures 15 or 16. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneousl during turn-off, in most cases, with the base-to-emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current condition allowable putting reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 19 gives the RBSOA characteristics.

td and tr HP 214 Equiv P.G. "IB

50

OV.

R<sub>B</sub> = 33 Ω

t<sub>r</sub>≤15 ns

VCC = 250 Vdc R<sub>L</sub> = 83 Ω IC = 3.0 Adc IB = 0.3 Adc

VCC

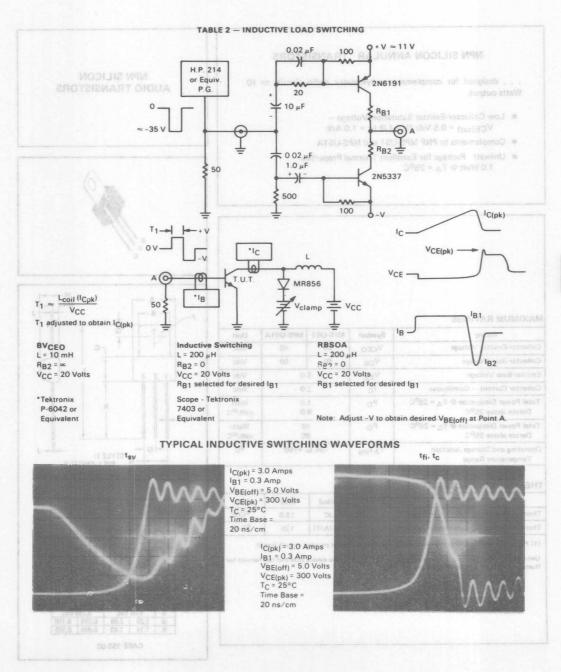
\*Tektronix P-6042 of Equivalent

Q+Vdc = 11 Vdc TABLE 1 - RESISTIVE LOAD SWITCHING ts and te 100 OV 20 2N6191 ≈ -35 ) 0.02 µF RB1 H.P. 214 10 µF or (O) A Equiv P.G. R<sub>B2</sub> 50.02 µF 50 \$ 2N5337 100 \$ 500

(0) \*IC \*IB 50 5 Vcc = Vcc = 250 IB1 = 0.3 Adc RB1 = 33 1 IB2 = 0.6 Adc R<sub>B2</sub> = 8.0 Ω RL = 83 Ω IC = 3.0 Add For VBE(off) = 5.0 V RB2 = 0 \Omega

\*Note: Adjust -V to obtain desired VBE(off) at Point A.





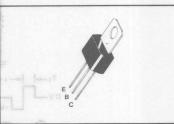


#### NPN SILICON ANNULAR TRANSISTORS

 $\ldots$  , designed for complementary symmetry audio circuits to 10 Watts output.

- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.5 Vdc (Max) @ IC = 1.0 Adc
- Complements to PNP MPS-U51 and MPS-U51A
- Uniwatt Package for Excellent Thermal Properties 1.0 Watt @ T<sub>A</sub> = 25°C

NPN SILICON AUDIO TRANSISTORS



3

#### MAXIMUM RATINGS

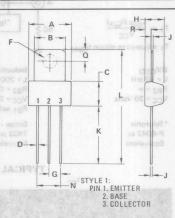
WAXINOW HATINGS				
Rating	Symbol	MPS-U01	MPS-U01A	Unit
Collector-Emitter Voltage	VCEO	30	40	Vdc
Collector-Base Voltage	VCB	0 40	50	Vdc
Emitter-Base Voltage	VEB	DE DON E	5.0	Vdc
Collector Current - Continuous	1c	2.0		Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD		1.0 3.0	Watt mW/ <sup>o</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	10 80		Watts mW/ <sup>o</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 t	o +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(1)	125	°C/W

(1)  $R_{\theta JA}$  is measured with the device soldered into a typical printed circuit board.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.



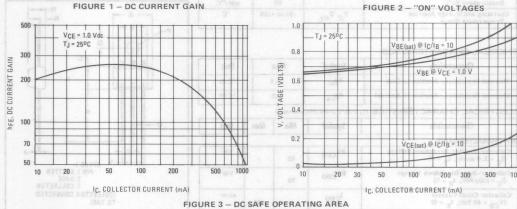
	MILLIN	TETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08	BSC	0.200 BSC	
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

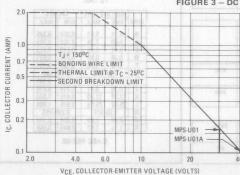
Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 0)		MPS-U01 MPS-U01A	BVCEO	30 40	_	Vdc
Collector-Base Breakdown Voltage (I $_{C}$ = 100 $\mu Adc$ , I $_{E}$ = 0)		MPS-U01 MPS-U01A	BVCBO	40 50		Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)			BVEBO	5.0	_	Vdc
Collector Cutoff Current ( $V_{CB}$ = 30 Vdc, $I_{E}$ = 0) ( $V_{CB}$ = 40 Vdc, $I_{E}$ = 0)			ICBO	LIFTER 1	0.1 0.1	μAdc
Emitter Cutoff Current (VBE = 3.0 Vdc, IC = 0)	voltage amplifier and		IEBO	uq-latensg	0.1	μAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)		T <sub>C</sub> = 25 <sup>9</sup> C	hFE) = 6	55 60 50	Power Dissi Jement to F	
Collector-Emitter Saturation Voltage	S STATE OF		VCE(sat)	1 - 1	0.5	Vdc
(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	2.11	aul-V	Surjust 2	T		Pating
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)	obV	0.0	VBE (on)		1.2	Vdc
DYNAMIC CHARACTERISTICS	ak-V	170	asy.		The state of the s	ov sastl-vot
Current-Gain—Bandwidth Product (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 10 Vdc, f = 20 MHz)	shV	0.0	f <sub>T</sub> v	50	- 10	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 1.0 MHz)	the W	9.1	C <sub>ob</sub>	3746	20	pF
1)Pulse Test: Pulse Width <300 µs, Duty Cycle ≤ 2.0%	JPNW/m	8.0				"CS avods a
Truise Test. Fulse Width < 300 µs, Duty Cycle < 2.0%						











There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on  $T_{J(pk)}=150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.



# NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

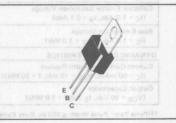
... designed for general-purpose, high-voltage amplifier and driver applications.

- High Power Dissipation PD = 10 W @ TC = 25°C
- Complement to PNP MPS-U52

#### NPN SILICON AMPLIFIER TRANSISTOR

#### MAXIMUM RATINGS

AMINON NATINGS			
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	40	Vdc
Collector-Base Voltage	v <sub>CB</sub>	60	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	I <sub>C</sub>	800	m Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1. 0 8. 0	Watt mW/°C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	P <sub>D</sub>	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C ,



#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta_{ m JC}}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{oldsymbol{ heta}_{\mathrm{JA}}}$	125	°C/W

#### ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

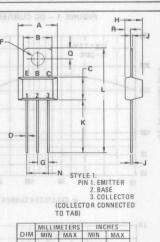
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		50		IVILLI
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BVCEO	40	-	Vdc
Collector-Base Breakdown Voltage $(I_C = 100 \mu Adc, I_E = 0)$	вусво	60	-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	СВО	TARRE	100	nAdc

#### ON CHARACTERISTICS

DC Current Gain $(I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 500 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$	h <sub>FE</sub>	50 50 30	300	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 150 mAdc, I <sub>B</sub> = 15 mAdc)	V <sub>CE</sub> (sat)	sistor: op=rarin	0.4	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 150 mAdc, I <sub>B</sub> = 15 mAdc)	V <sub>BE</sub> (sat)	a sel zon	1.3	Vdc

#### DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I <sub>C</sub> = 20 mAdc, V <sub>CE</sub> = 20 Vdc, f = 100 MHz)	ons $w_{\mathbf{T}}^{-1}$ reduce the linuxetic	100	-	MHz
Output Capacitance	Cob			pF
$(v_{CB} = 10 \text{ Vdc}, I_{E} = 0, f = 100 \text{ kHz})$			20	



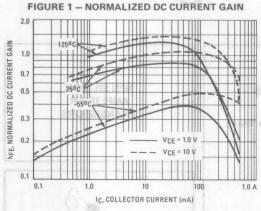
	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	9.14	9.53	0.360	0.375	
В	6.60	7.24	0.260	0.285	
C	5.41	5.66	0.213	0.223	
D	0.38	0.53	0.015	0.021	
F	3.18	3.33	0.125	0.131	
G	2.54	BSC	0.100 BSC		
H	3.94	4.19	0.155	0.165	
J	0.36	0.41	0.014	0.016	
K	12.07	12.70	0.475	0.500	
L	25.02	25.53	0.985	1.005	
N	5.08 BSC		0.200 BSC		
Q	2.39	2.69	0.094	0.106	
R	1.14	1.40	0.045	0.055	

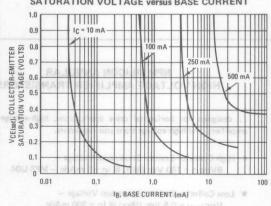
CASE 152-02

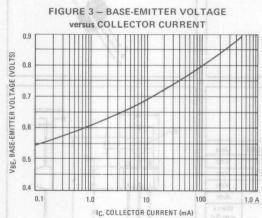
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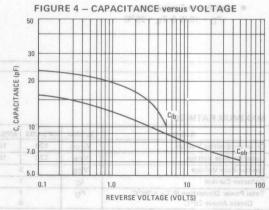
MOTOROLA

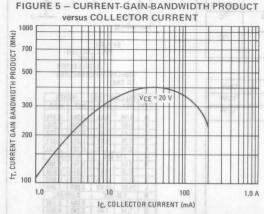


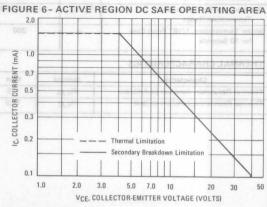














# NPN SILICON ANNULAR HIGH VOLTAGE AMPLIFIER TRANSISTORS

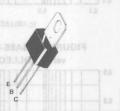
... designed for horizontal drive applications, high-voltage linear amplifiers, and high-voltage transistor regulators.

High Collector-Emitter Breakdown Voltage —
 BVCEQ = 180 Vdc (Min) @ IC = 1 mAdc — MPS-U04

SATURATION VOLTAGE VIPULE BASE CURRENT

- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 0.5 Vdc (Max) @ IC = 200 mAdc
- High Power Dissipation = TOASA = A SEUDIA PD = 10 W @ TC = 25°C

NPN SILICON AMPLIFIER TRANSISTORS



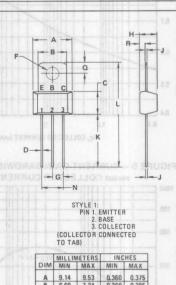
3

#### MAYIMIIM BATING

MAXIMUM RATINGS			8 1111	
Rating	Symbol	MPS-U03	MPS-U04	Unit
Collector-Emitter Voltage	VCEO	120	180	Vdc
Collector-Base Voltage	VCB	120	180	Vdc
Emitter-Base Voltage	VEB	0.8	5	Vdc
Collector Current	l <sub>C</sub>	1.0	1 A.0.1	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate Above 25°C	PD		1	Watts mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate Above 25°C	P <sub>D</sub> 10		Watts mW/ <sup>O</sup> C	
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 t	0 +150	°C
Solder Temperature, 1/16" From Case for 10 Seconds		2	60	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	125	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W



ELTH	MILLI	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100	BSC
Н	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08	BSC	0.20	DBSC
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

FIGURE 3 - DC CURRENT GAIN

#### TYPICAL CHARACTERISTICS (Continued)

FIFCTRICAL	CHARACTERISTICS	(TA = 250C unless otherwise noted)	

Characteristic		Symbol	Min	Max	Unit			
OFF CHARACTERISTICS								
Collector-Emitter Breakdown Voltage (IC = 1.0 mAdc, IB = 0)	MPS-U03 MPS-U04	BVCEO	120 180		Vdc			
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	MPS-U03 MPS-U04	BVCBO	120 180	A 0'5" 30A	Vdc			
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 µAdc, I <sub>C</sub> = 0)		BVEBO	5.0		Vdc			
Collector Cutoff Current (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 150 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub>	MPS-U03 MPS-U04	ICBO	094 —08 	0.1 0.1	μAdc			

#### ON CHARACTERISTICS (1)

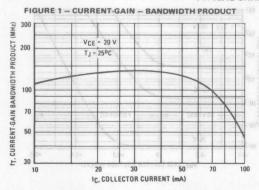
DC Current Gain (IC = 10 mAde, VCE = 10 Vdc)		hFE WOR	40	OLLECTOR SATU	FIGURE 5 - C
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 20 mAdc)	181	VCE(sat)	1111	0.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 1.0 Vdc)	8.0 1	V <sub>BE</sub> (on)	- t	1.0	Vdc

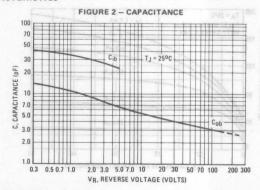
#### DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 20 Vdc, f = 20 MHz)	fτ	35		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	C <sub>ob</sub>	-1-1	12	pF
Input Capacitance (VBE = 0.5 Vdc, IC = 0, f = 100 kHz)	C <sub>ib</sub>	12-11	110	pF

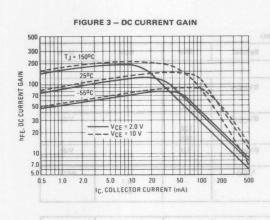
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

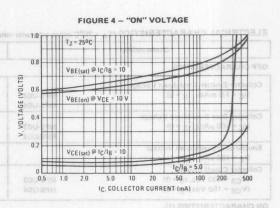
#### HOIDER PROTUD ROTGELLIOD - TYPICAL CHARACTERISTICS POSTERSTOARARD ROTGELLIOD - CERUSIA

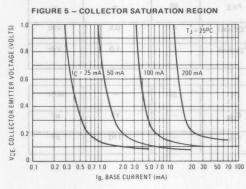


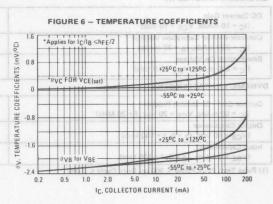


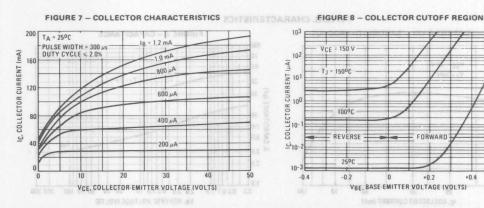
#### TYPICAL CHARACTERISTICS (Continued)

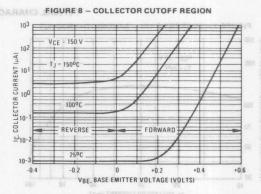












# MOTOROLA

#### TYPICAL CHARACTERISTICS (Continued)

FIGURE 9 - THERMAL RESPONSE

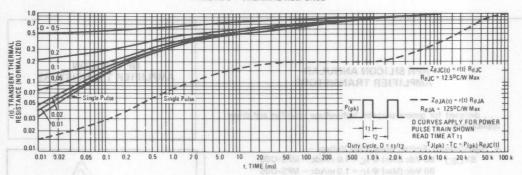
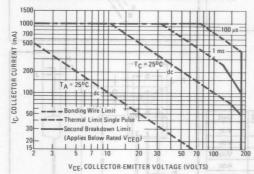


FIGURE 10 - ACTIVE REGION SAFE-OPERATING AREA



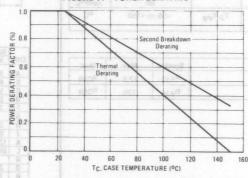
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

High Power Dissipation - PD = 10 W © TC = 25°C

The data of Figure 10 is based on T<sub>C</sub> = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when T<sub>C</sub> ≥ 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 10 may be found at any case temperature by using the appropriate curve on

TJ(pk) may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 11 - POWER DERATING





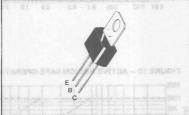
# NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

FIGURE 9 - THERMAL RESPONSE

 $\ldots$  designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 60 Vdc (Min) @ IC = 1.0 mAdc MPS-U05
   80 Vdc (Min) @ IC = 1.0 mAdc MPS-U06
- High Power Dissipation  $-P_D = 10 \text{ W} @ T_C = 25^{\circ}\text{C}$
- Complements to PNP MPS-U55 and MPS-U56

NPN SILICON AMPLIFIER TRANSISTORS



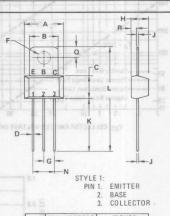
3

#### MAXIMUM RATINGS

bound a Rating of stoom and aw	Symbol	MPS-U05	MPS-U06	Unit
Collector-Emitter Voltage 198 and police	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	1 1 4	.0	Vdc
Collector Current - Continuous	Ic	2.0		Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0		Watt mW/ <sup>o</sup> C
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	BMITAN 10 80		Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	125	°C/W



	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100	DBSC
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
F	25.02	25.53	0.985	1.005
N	5.08	BSC	0.200	BSC
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

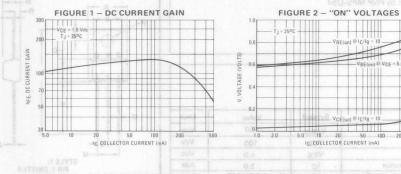
CASE 152-02

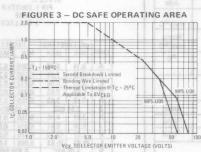
TE. CASE TEMPERATURE (PC)

#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted)

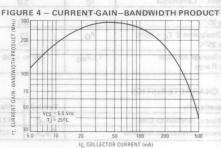
Characteristic	1	Symbol	Min	Тур	Max	Unit
FF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	MPS-U05 MPS-U06	BVCEO	60 80		-	Vdc
Emitter-Base Breakdown Voltage ( $I_E = 100 \mu Adc, I_C = 0$ )		BVEBO	4.0	-	- 1	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	MPS-U05 MPS-U06	I <sub>CBO</sub>	AJULANA I	NPN SHJICON	100 100	nAdc
N CHARACTERISTICS						
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, $V_{CE}$ = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, $V_{CE}$ = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, $V_{CE}$ = 1.0 Vdc)	and the form	hFE	80 60	125 100 55		-
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)		VCE(sat)	_	0.18 0.1	200755 0.4 -	ilggs Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)		V <sub>BE</sub> (on)		0.74	1.2	Vdc
MALL-SIGNAL CHARACTERISTICS				DESTRUCTION OF THE STATE OF		in a
Current-Gain—Bandwidth Product (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)		fT	50	150	- 533-4	MHz
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 100 kHz)		C <sub>ob</sub>	01.034.01-	6.0	12	pF

(1)Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.





There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> — V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.



The data of Figure 3 is based on  $T_{J(pk)}=150^{\circ}C;\,T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

mitter-Base Broakdown Voltage

# NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver

- High Collector-Emitter Breakdown Voltage –
   BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc
- High Power Dissipation PD = 10 W @ TC = 25°C
- Complement to PNP MPS-U57

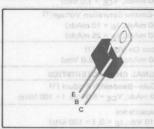
#### MAXIMUM RATINGS

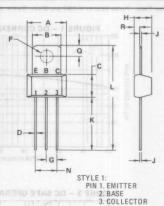
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	100	Vdc
Collector-Base Voltage	VCB	100	Vdc
Emitter-Base Voltage	VEB	4.0	Vdc
Collector Current - Continuous	1c	2.0	Adc
Total Power Dissipaton @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	8.0	Watt mW/ <sup>o</sup> C
Total Power Dissipaton @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80	Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	125	oC/W

# NPN SILICON AMPLIFIER TRANSISTOR





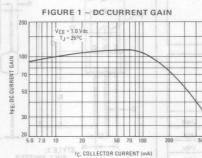
	MILLI	WETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100	BSC
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08	BSC	0.200	BSC
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

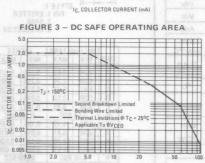
CASE 152-02

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage <sup>(1)</sup> (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BVCEO	100	-	-	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)	BVEBO	4.0	-	-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	ІСВО		-	100	nAdc
ON CHARACTERISTICS ART					
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	ROTSIZIV	60 30	110 65 33	NPN SICH	-
Collector-Emitter Saturation Voltage (1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)	Misses VCE(sat)	animul bas a	0.18 0.1	0.4 ovi	
Base-Emitter On Voltage (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)	V <sub>BE</sub> (on)	egatioV nw	0.76	1.2 	Vdc
SMALL-SIGNAL CHARACTERISTICS	0	bAm 0,1 = 3	Vdc (Nim) @ I	VCEQ = 309	8
Current-Gain—Bandwidth Product (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)	f <sub>T</sub>		150 mm (xeM) abV-3		MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	C <sub>ob</sub>		6.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		

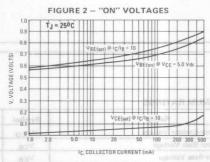
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

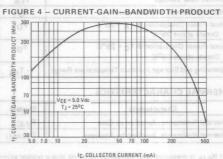




VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I  $C-V_{\hbox{\scriptsize CE}}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.





The data of Figure 3 is based on  $T_{J(pk)}$  = 150  $^{\rm OC}$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

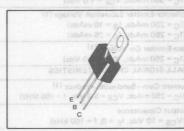


#### NPN SILICON ANNULAR TRANSISTOR

 $\epsilon_{\rm v}$  , designed for high-voltage video and luminance output stages in TV receivers.

- High Collector-Emitter Breakdown Voltage BVCEO = 300 Vdc (Min) @ IC = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.75 Vdc (Max) @ IC = 30 mAdc
- Low Collector-Base Capacitance —
   C<sub>cb</sub> = 3.0 pF (Max) @ V<sub>CB</sub> = 20 Vdc

NPN SILICON A DESCRIPTION OF THE SILICON A DE



MAXIMUM RATINGS

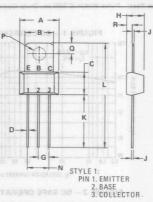
	and the second		- K
Rating Repair	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	300	Vdc
Collector-Base Voltage	VCB	300	Vdc
Emitter-Base Voltage	VEB	6.0	Vdc
Collector Current - Continuous AD TM38 AUG -	A B TO DIA	0.5	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	1.0 8.0	Watt mW/ <sup>o</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80	Watts mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	TIT	-55 to +150	00

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(1)	125	°C/W

(1)  $R_{ heta JA}$  is measured with the device soldered into a typical printed circuit board.

depending an conditions. At high case reimperatures, thermal limitations will reduce the poyen that can be handled to vehicle less



	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08	BSC	0.200	BSC
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

3

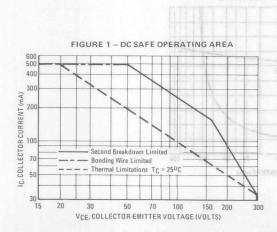
# ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		3,62		
Collector-Emitter Breakdown Voltage (1) (I C = 1.0 mAdc, I B = 0)	BVCEO	300	-	Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)	BVCBO	300	-	Vdc
Emitter-Base Breakdown Voltage	BVEBO	6.0	2.0	Vdc
Collector Cutoff Current ( $V_{CB} = 200 \text{ Vdc}$ , $I_E = 0$ )	I CBO	-	0.2	μAdc
Emitter Cutoff Current $(V_{BE} = 6.0 \text{ Vdc}, I_C = 0)$	IEBO '	-	0.1	μAdc

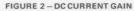
DC Current Gain	hFE			
(I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc)		25	1	
(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 10 Vdc)		40		4
(I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)		40	- du2	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 3.0 mAdc)	VCE(sat)	- 11	0.75	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 30 mAdc, V <sub>CE</sub> = 10 Vdc)	VBE(on)		0.85	Vdc

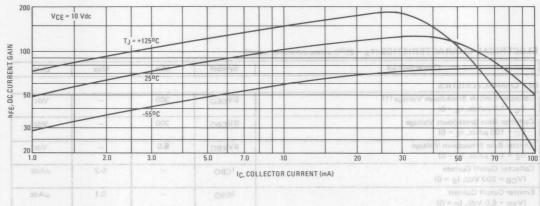
Current-Gain-Bandwidth Product (1) (I C = 10 mAdc, VCE = 20 Vdc, f = 100 MHz)	fT	45		MHz
Collector-Base Capacitance (V <sub>CB</sub> = 20 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>cb</sub>	18 20	3,0	g <sub>B</sub> pF

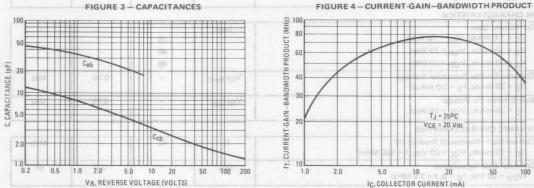
(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤ 2%.

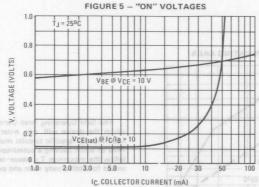


The Safe Operating Area Curves indicate  $I_C - V_{CE}$  limits below which the device will not enter second breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum  $T_J$ , power-temperature derating must be observed for both steady state and pulse power conditions.









#### NPN SILICON ANNULAR RF TRANSISTOR

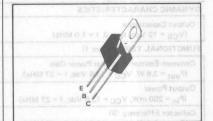
... designed for use in Citizen-Band and other high-frequency communications equipment operating to 30 MHz. Higher breakdown voltages allow a high percentage of up-modulation in AM circuits. This device is designed to be used with the MPS8000 driver and the MPS8001 RF oscillator.

- Output Power = 3.5 W (Min) @ V<sub>CC</sub> = 13.6 Vdc
- Power Gain = 11.5 dB (Min)
- High Collector-Emitter Breakdown Voltage BVCES ≥ 65 Vdc
- DC Current Gain —
   Linear to 500 mAdc



# RF POWER OUTPUT

NPN SILICON



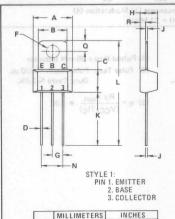
## MAXIMUM RATINGS 5 of 19 1980 Series Courted to 1991

the comment of the state of the	with the state of	Jaly Bart Ton	11
rewood la Rating and periktuon naris be	Symbol	Value	Unit
Collector-Emitter Voltage	VCES	65	Vdc
Emitter-Base Voltage	VEB	3.0 talul	Vdc
Collector Current Continuous	1c	500	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD see	1.0 8.0	Watt mW/ <sup>o</sup> C
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	10 80	Watt mW/ <sup>o</sup> C
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JA$	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(1)	125	°C/W

(1)  $R_{ heta JA}$  is measured with the device soldered into a typical printed circuit board.



	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	9.14	9.53	0.360	0.375	
В	6.60	7.24	0.260	0.285	
C	5.41	5.66	0.213	0.223	
D	0.38	0.53	0.015	0.021	
F	3.18	3.33	0.125	0.131	
G	2.54	BSC	0.100 BSC		
Н	3.94	4.19	0.155	0.165	
J	0.36	0.41	0.014	0.016	
K	12.07	12.70	0.475	0.500	
L	25.02	25.53	0.985	1.005	
N	5.08	BSC	0.200 BSC		
0	2.39	2.69	0.094	0.106	
R	1.14	1.40	0.045	0.055	

CASE 152-02

3

MOTOROLA

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS				7.2		
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 150 mAdc, V <sub>BE</sub> = 0)	son	BVCES	65 A AAJI	ON ANN	NPN SILIC	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 1.0 mAdc, I <sub>C</sub> = 0)	-mao yaneupi	BVEBO	3.0 bns bns8-n	se in Citize	e rot bengin	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 50 Vdc, I <sub>E</sub> = 0)		annaman.		gh percent	in a wolle in	mAdc
ON CHARACTERISTICS	000 tana 1090 ta	DOODE THE S	M HENR LONG		001 RF oscill	MPS8
DC Current Gain (2) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 10 Vdc)		hEE 0.8			tput Power	
DYNAMIC CHARACTERISTICS				(DIN) BD C.	IT = HUGE YOU	NO.4 W
Output Capacitance (V <sub>CB</sub> = 12 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)		Cob	DOA UNODS	Vac	40	pF
FUNCTIONAL TEST (Figure 1)					CONTENT State	
Common-Emitter Amplifier Power Gain (P <sub>out</sub> = 3.5 W, V <sub>CC</sub> = 13.6 Vdc, f = 27 MHz)		GPE	11.5	=	-	dB
Output Power (P <sub>in</sub> = 250 mW, V <sub>CC</sub> = 13.6 Vdc, f = 27 MHz)		Pout	3.5	-	-	Watts
Collector Efficiency (3) (P <sub>out</sub> = 3.5 W, V <sub>CC</sub> = 13.6 Vdc, f = 27 MHz)		η	-	70	-	%
Percentage Up-Modulation (4) (f = 27 MHz)		-	-	85	-	%

(1) Pulsed thru a 25 mH Inductor

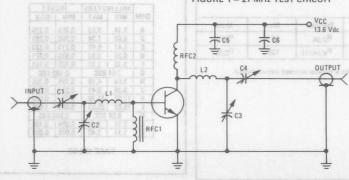
(2) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤ 2.0%.

(3) 
$$\eta = \frac{\mathsf{RF}\,\mathsf{P}_{\mathsf{out}}}{(\mathsf{V}_{\mathsf{CC}})\,(\mathsf{I}_{\mathsf{C}})} \bullet 100$$

(4) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P<sub>C</sub>) to 3.5 Watts with V<sub>CC</sub> = 13.6 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the  $V_{CC}$  to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

> Percentage Up-Modulation = •100

FIGURE 1 - 27 MHz TEST CIRCUIT



C1, C2 9.0-180 pF ARCO 463 or Equivalent

C3, C4 5.0-80 pF ARCO 462 or Equivalent C5 0.02 µF Ceramic Disc

C6 0.1 µF Ceramic Disc

RFC1 4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B

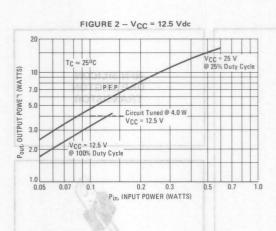
RFC2 26 Turns #22 Enameled Wire (2 Layers -13 Turns Each Layer) ¼" Inner Diameter

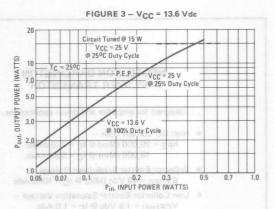
0.22 µH Molded Choke

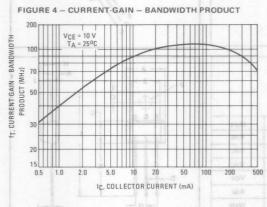
0.68 µH Molded Choke

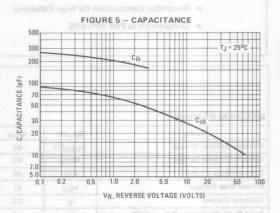


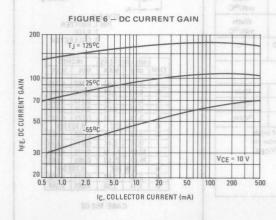
#### POWER OUTPUT

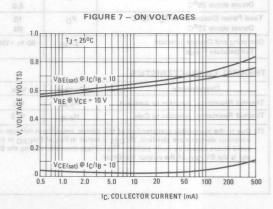








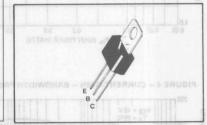




#### NPN SILICON DARLINGTON AMPLIFIER TRANSISTOR

- . . . designed for amplifier and driver applications.
- High DC Current Gain —
   hFE = 25,000 (Min) @ IC = 200 mAdc
   15,000 (Min) @ IC = 500 mAdc
- Collector-Emitter Breakdown Voltage BV CES = 40 Vdc (Min) @ IC = 100  $\mu$ Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.5 Vdc @ IC = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to PNP MPS-U95

NPN SILICON DARLINGTON TRANSISTOR



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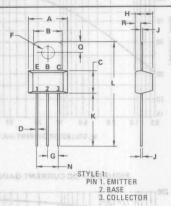
#### MAXIMUM RATINGS

WAXIWUW RATINGS			
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub> (1)	40	Vdc
Collector-Emitter Voltage	VCES	40	Vdc
Collector-Base Voltage	VCB	50	Vdc
Emitter-Base Voltage	VEB	12	Vdc
Collector Current	Ic	2.0	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0	Watt mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD PD	10 80	Watts , mW/ <sup>O</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	125	°C/W
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W

(1) Due to the monolithic construction of this device, breakdown voltages of both transistor elements are identical. BV<sub>CES</sub> is tested in lieu of BV<sub>CEO</sub> in order to avoid errors caused by noise pickup. The voltage measured during the BV<sub>CES</sub> test is the BV<sub>CEO</sub> of the output transistor.



	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

FLECTRICAL CHARACTERISTICS (To = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ( $I_C = 100 \mu Adc$ , $V_{BE} = 0$ )	BVCES	40	-		Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)	BVCBO	50	-		Vdc
Emitter-Base Breakdown Voltage (IE = 10 $\mu$ Adc, IC = 0)	BVEBO	12		3046	Vdc
Collector Cutoff Current (VCB = 30 Vdc, IE = 0)	СВО	8.0	50 10	100	nAdc
Emitter Cutoff Current and action and (VEB = 10 Vdc, IC = 0)	IEBO	REENTAMP)	, coule <del>s</del> tan ch	100	nAdc

MO	CHA	RA	CTE	RI	STI	CS(1	)

DC Current Gain 3 3 AUT AR 3 90 3 1 - 8 3 AUDIA	hFE	VOLTABES	MC" - E BE	CHENTY	-
(I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc)		25,000	65,000	150,000	1105
(I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 5.0 Vdc)		15,000	35,000	2595	UT-
(I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		4,000	12,000		2.0
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)	VCE (sat)		1.2	1.5	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)	VBE(sat)		1.85	2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)	VBE (on)		1.7	2.0	Vdc

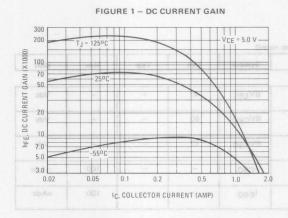
## DYNAMIC CHARACTERISTICS

Small-Signal Current Gain (1) (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)	h <sub>fe</sub>	1.0	3.2		
Collector Base Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>cb</sub>	11.30.5 (46.117 (A))P1	2.5	6.0	pF

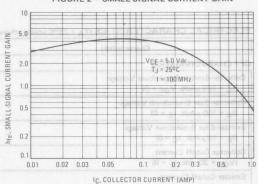
<sup>(1)</sup> Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

Uniwatt darlington transistors can be used in any number of low power applications, such as relay drivers, motor control and as general purpose amplifiers. As an audio amplifier these devices, when used as a complementary pair, can drive 3.5 watts into a 3.2 ohm speaker using a 14 volt supply with less than one per cent distortion. Because of the high gain the base drive requirement is as low as 1 mA in this application. They are also useful as power drivers for high current application such as voltage regulators.





#### FIGURE 2 - SMALL-SIGNAL CURRENT GAIN



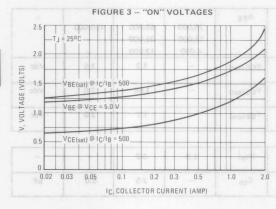


FIGURE 4 - TEMPERATURE COEFFICIENT

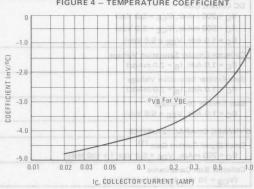
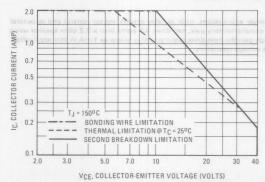


FIGURE 5 - DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

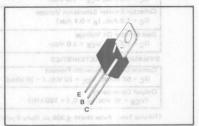
The data of Figure 5 is based on  $T_J(\rm pk)$  = 150°C;  $T_C$  is variable depending on conditions. At high case temperatures, thermal liminary tations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### PNP SILICON ANNULAR TRANSISTORS

. . . designed for complementary symmetry audio circuits to 5 Watts output.

- Excellent Current Gain Linearity 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage VCE(sat) = 0.7 Vdc (Max) @ IC = 1.0 Adc
- Complements to NPN MPS-U01 and MPS-U01A
- Uniwatt Package for Excellent Thermal Properties 1.0 Watt @ TA = 25°C

#### PNP SILICON **AUDIO TRANSISTORS**



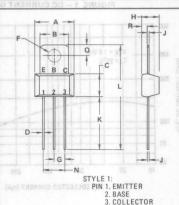
#### MAXIMUM RATINGS

Vel - Rating	Symbol	MPS-U51	MPS-U51A	Unit
Collector-Emitter Voltage	VCEO	30	40	Vdc
Collector-Base Voltage	VCB	40	50	Vdc
Emitter-Base Voltage	VEB	5.0		Vdc
Collector Current — Continuous	Ic	2.0		Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0		Watt mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80		Watts mW/OC
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150		°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

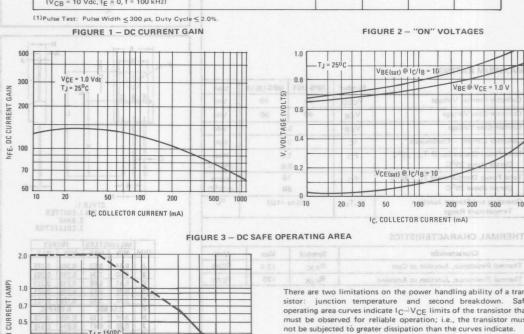
The data of Figure 3 is based on  $T_{J(pk)}=180^{6}\mathrm{C}$ ,  $T_{C}$  is variable depinding on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to value



	MILLIN	MILLIMETERS		HES
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
В	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200	BSC
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	MPS-U51 MPS-U51A	BVCEO	30 40		Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 $\mu$ Adc, I <sub>E</sub> = 0)	MPS-U51 MPS-U51A	BVCBO	40 50	-	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 100 μAdc, I <sub>C</sub> = 0)		BVEBO	5.0	-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	MPS-U51 MPS-U51A	ICBO AT AAJ	UNN <del>I</del> A M	0.1	μAdc
Emitter Cutoff Current (V <sub>BE</sub> = 3.0 Vdc, I <sub>C</sub> = 0)	rudio circuite to 5 Watts	IEBO	lynsan <del>o</del> msto	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 1.0 Vdc)  (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)				m3-Totastii m3-Totastii Eat) = 0.7	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.1 Adc)	roperties -	VCE (sat)	or Exceller	0.7 age son 7 1	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)		V <sub>BE</sub> (on)	0.02	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 10 Vdc, f = 20 MHz)		fT	50	-	MHz
Output Capacitance (VCR = 10 Vdc, IF = 0, f = 100 kHz)		Cob	-	30	pF



IC, COLLECTOR CURRENT (AMP) T.1 = 150°C Secondary Breakdown Limited 0.3 **Bonding Wire Limited** Thermal Limitations @ 0.2 Applicable To BVCEO MPS-U51 0.1 2.0 3.0 30 VCE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must

The data of Figure 3 is based on  $T_{J(pk)}$  = 150°C;  $T_C$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

r 1 "



#### PNP SILICON ANNULAR TRANSISTOR

- ... designed for general-purpose amplifier and driver applications.
- Complement to NPN MPS-U02

## PNP SILICON AMPLIFIER TRANSISTOR

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	40	Vdc
Collector-Base Voltage	V <sub>CB</sub>	60	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	5. 0	Vdc
Collector Current - Continuous	I <sub>C</sub>	1.5	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C  Derate above 25°C	- D PD DIA	1. 0 8. 0	Watt mW/°C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	P <sub>D</sub>	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub> <sup>(1)</sup>	-55 to +150	°C

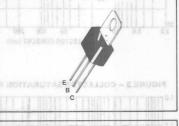
#### THERMAL CHARACTERISTICS

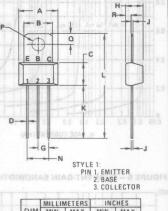
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R 0 JA (1)	125	°C/W

#### ELECTRICAL CHARACTERISTICS (TA = 25 °C unless otherwise noted)

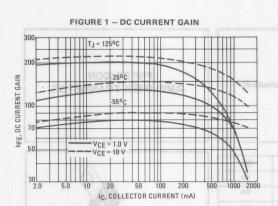
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS		0.10		80 200 509
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BVCEO	40		Vdc
Collector-Base Breakdown Voltage $(I_C = 100 \mu\text{Adc}, I_E = 0)$	вусво	60	-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	СВО	-	100	nAdcroug
ON CHARACTERISTICS (2)	MALE	1		
DC Current Gain $(I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 150 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 500 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$	h <sub>FE</sub>	50 50 30	300	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 150 mAdc, I <sub>B</sub> = 15 mAdc)	V <sub>CE(sat)</sub>	100 g	0.4	Vdc
Base-Emitter Saturation Voltage (1 <sub>C</sub> = 150 mAdc, 1 <sub>B</sub> = 15 mAdc)	V <sub>BE(sat)</sub>	- 42 3	1.3	Vdc
DYNAMIC CHARACTERISTICS		1 1 2		
Current-Gain-Bandwidth Product (2) (I <sub>C</sub> = 20 mAdc, V <sub>CE</sub> = 20 Vdc, f = 100 MHz)	f <sub>T</sub>	100	-	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	Cob	1.0	24	pF

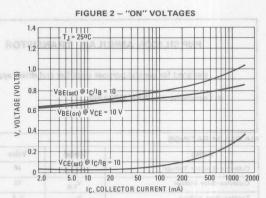
- (1) RøJA is measured with device soldered into a typical printed circuit board (2) Pulse Test: Pulse Width≤300 µs, Duty Cycle≤2.0%

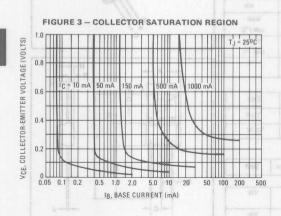


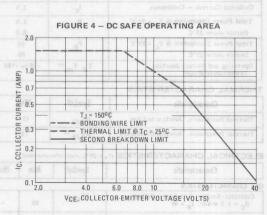


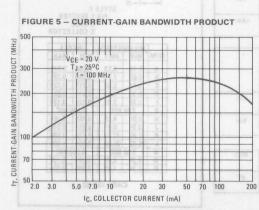
DIM	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54	BSC	0.10	DBSC
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08	BSC	0.20	O BSC
0	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

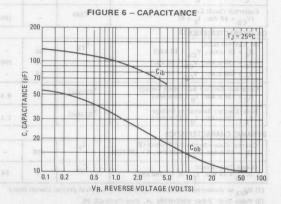












#### PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage -BVCEO = 60 Vdc (Min) @ IC = 1.0 mAdc - MPS-U55 80 Vdc (Min) @ IC = 1.0 mAdc - MPS-U56
- High Power Dissipation PD = 10 W @ TC = 25°C
  - Complements to NPN MPS-U05 and MPS-U06

## PNP SILICON AMPLIFIER TRANSISTORS

(Ig = 60 mAdd; Vgg = 1.0 Vdd)



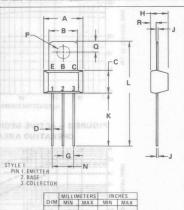
Rating	Symbol	MPS-U55	MPS-U56	Unit
Collector-Emitter Voltage	VCEO	60	80	Vdc
Collector-Base Voltage	VCB	60	80	Vdc
Emitter-Base Voltage	VEB	4	.0	Vdc
Collector Current - Continuous	1c	5.6.2	.0	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0		Watt mW/ <sup>o</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD		0	Watts mW/ <sup>o</sup> C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to	+150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(1)	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	12.5	°C/W

(1)  $R_{ heta JA}$  is measured with the device soldered into a typical printed circuit board.

This diets of Figure 3 is based on Tufpty - 150°C; To it withold depending on combilions. At high case temperatures, therms limitations will reduce the power that can be handled to values less invitations.



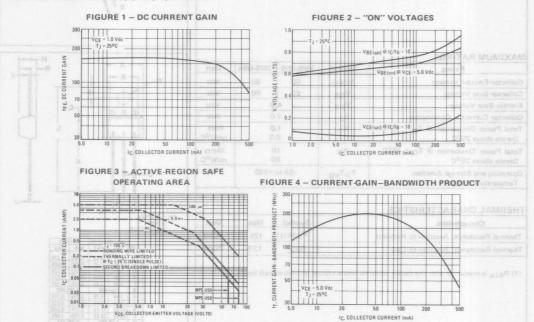
	MILLIN	MILLIMETERS		HES	
DIM	MIN	MAX	MIN	MAX	
A	9.14	9.53	0.360	0.375	
В	6.60	7.24	0.260	0.285	
C	5.41	5.66	0.213	0.223	
D	0.38	0.53	0.015	0.021	
F	3.18	3.33	0.125	0.131	
G	2.54	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165	
J	0.36	0.41	0.014	0.016	
K	12.07	12.70	0.475	0.500	
L	25.02	25.53	0.985	1.005	
N	5.08	BSC	0.200	BSC	
0	2.39	2.69	0.094	0.106	
R	1.14	1.40	0.045	0.055	

Collector Connected to Tab CASE 152-02

#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted)

Characteristic	7	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage <sup>(1)</sup> (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	MPS-U55 MPS-U56	BVCEO	60 80	_	_	Vdc
Emitter-Base Breakdown Voltage (IE = 100:µAdc, IC = 0)		BVEBO	4.0	-	-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	MPS-U55 MPS-U56	ICBO RA	N ANTOULA TRANSIST	NP STLICO	100 100	nAdd
ON CHARACTERISTICS						
DC Current Gain (1) (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	nd driver	s 191 hFE 16 90	80 50	160 130 80	tesigned for	
Collector-Emitter Saturation Voltage(1) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)	i i		10 = 1.0 mAr	0.22 0.15	0.5 V8	Vdc
Base-Emitter On Voltage (1) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)		V <sub>BE</sub> (on)	= 10 <u>W</u> @ T <sub>C</sub> 05 and MPS=	0.78	1.2	Vdc
MALL-SIGNAL CHARACTERISTICS						
Current-Gain-Bandwidth Product (1) (IC = 250 mAdc, VCE = 5.0 Vdc, f = 100 MHz)		fT	50	100	-	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)		C <sub>ob</sub>	-	10	15	pF

(1)Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I  $_{\rm C}$  – VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second-breakdown.

(IC = 1.0 mAde, IB = 0) Emitter-Bess Bresk-down



#### PNP SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage BVCEO = 100 Vdc (Min) @ IC = 1.0 mAdc
  - High Power Dissipation PD = 10 W @ TC = 25°C
  - Complement to NPN MPS-U07

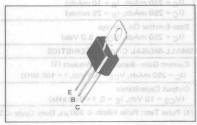
#### MAXIMUM RATINGS

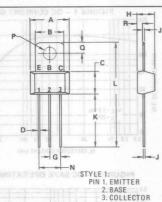
Rating	Symbol	Value	Unit		
Collector-Emitter Voltage	VCEO	100	Vdc		
Collector-Base Voltage	VCB	100	Vdc		
Emitter-Base Voltage CMAG-MIAD TM	VEB	4.0	Vdc		
Collector Current - Continuous	IC	2.0	Adc		
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0	Watt mW/°C		
Total Power Dissipation @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	10 80	Watts mW/°C		
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C		

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	ReJC	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

AMPLIFIER TRANSISTOR PNP SILICON



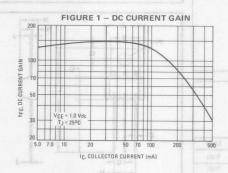


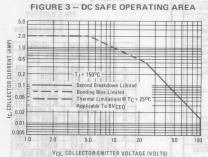
1000	MILLIMETERS		INC	HES	
DIM	MIN	MAX	MIN	MAX	
Α	9.14	9.53	0.360	0.375	
В	6.60	7.24	0.260	0.285	
C	5.41	5.66	0.213	0.223	
D	0.38	0.53	0.015	0.021	
F	3.18	3.33	0.125	0.131	
G	2.54	BSC	0.100	O BSC	
H	3.94	4.19	0.155	0.165	
J	0.36	0.41	0.014	0.016	
K	12.07	12.70	0.475	0.500	
L	25.02	25.53	0.985	1.005	
N	5.08	BSC	0.200	O BSC	
0	2.39	2.69	0.094	0.106	
R	1.14	1.40	0.045	0.055	

CASE 152-02

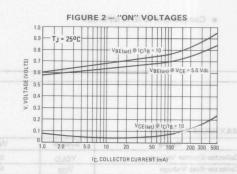
Characteristic	Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	BVCEO	100	-	-	Vdc
Emitter-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	BVEBO	4.0		-	Vdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0)	ІСВО	-	-	100	nAdo
ON CHARACTERISTICS (1)		ANNULAR	IP SILICON	19	
DC Current Gain (I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 1.0 Vdc)	hFE 8	60 30	140 65 30	A	-
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 10 mAdc) (I <sub>C</sub> = 250 mAdc, I <sub>B</sub> = 25 mAdc)	VCE(sat)	lugh_voltage	0.24 0.15	0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 250 mAdc, V <sub>CE</sub> = 5.0 Vdc)	V <sub>BE</sub> (on)	-	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS		- costloV no	nither Breakdon	Collector-Er	iniH a
Current-Gain-Bandwidth Product (1) (IC = 250 mAdc, VCE = 5.0 Vdc, f = 100 MHz)	fT	on Am 50 = 3	@ (m100 bV	Vose <del>o</del> - 10i	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 100 kHz)	C <sub>ob</sub>	- Tewni	10 = d9 – noitso	15 Power Dies	pF

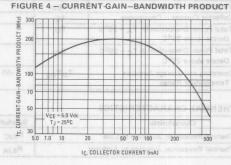
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.





There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.





The data of Figure 3 is based on  $T_{J(pk)}$  = 150 °C;  $T_C$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

. , . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

Complement to NPN Type MPS-U10

PNP SILICON HIGH VOLTAGE TRANSISTOR

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	300	Vdc
Collector-Base Voltage	VCB	300	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current - Continuous	1c	500	mAdc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0	Watt mW/°C
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	Re JC	12.5	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(1)	125	°C/W

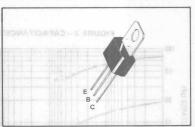
#### ELECTRICAL CHARACTERISTICS (TA = 25°C unless otherwise noted)

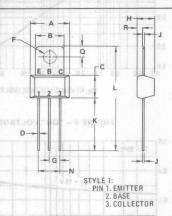
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Emitter Breakdown Voltage (2) 30 3 3 4 4 5 4 10 F	BVCEO	300		Vdc
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 μAdc, I <sub>E</sub> = 0)	BVCBO	300	-11	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 μAdc, I <sub>C</sub> = 0)	BVEBO	5.0	- 4	Vdc
Collector Cutoff Current (VCB = 200 Vdc, IE = 0)	СВО	193 (1	0.2	μAdo
Emitter Cutoff Current (VBE = 3.0 Vdc, IC = 0)	IEBO	G B B	0.1	μAdd
ON CHARACTERISTICS	toe	2	141	
DC Current Gain (2) ((c = 1.0 mAdc; VCE = 10 Vdc) ((c = 10 mAdc; VCE = 10 Vdc) ((c = 30 mAdc; VCE = 10 Vdc)	hFE 82	25 30 30	- 1	V
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 20 mAdc, I <sub>B</sub> = 2.0 mAdc)	VCE (sat)		0.75	Vdc
Base-Emitter Saturation Voltage (I <sub>C</sub> = 20 mAdc, I <sub>B</sub> = 2.0 mAdc)	VBE (sat)	1 5	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (2) (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 20 Vdc, f = 100 MHz)	fT	60		MH:
Collector Ress Connectance	C.			

(1)  $R_{ heta JA}$  is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

(V<sub>CB</sub> = 20 Vdc, I<sub>E</sub> = 0, f = 1.0 MHz)

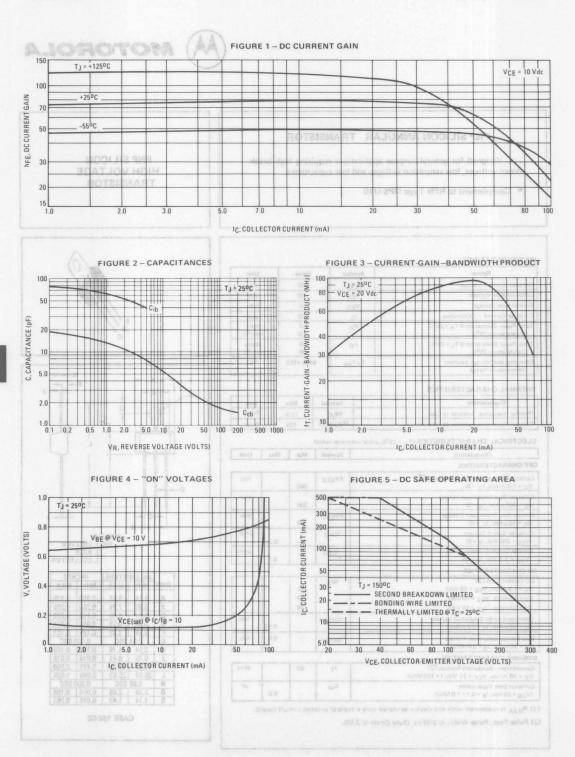




	MILLIMETERS		INC	HES	
DIM	MIN	MAX	MIN	MAX	
A	9.14	9.53	0.360	0.375	
В	6.60	7.24	0.260	0.285	
C	5.41	5.66	0.213	0.223	
D	0.38	0.53	0.015	0.021	
F	3.18	3.33	0.125	0.131	
G	2.54 BSC		0.100 BSC		
H	3.94	4.19	0.155	0.165	
J	0.36	0.41	0.014	0.016	
K	12.07	12.70	0.475	0.500	
L	25.02	25.53	0.985	1.005	
N	5.08 BSC		0.200 BSC		
0	2.39	2.69	0.094	0.106	
R	1.14	1.40	0.045	0.055	

CASE 152-02





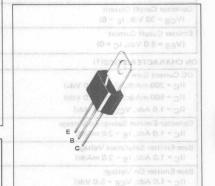


# PNP SILICON DARLINGTON AMPLIFIER TRANSISTOR

. . . designed for amplifier and driver applications.

- High DC Current Gain
  - hFE = 25,000 (Min) @ I<sub>C</sub> = 200 mAdc 15,000 (Min) @ I<sub>C</sub> = 500 mAdc
- Collector-Emitter Breakdown Voltage  $BVCES = 40 \text{ Vdc (Min)} @ IC = 100 \mu Adc$
- Low Collector-Emitter Saturation Voltage VCE(sat) = 1.5 Vdc @ IC = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to NPN MPS-U45

# PNP SILICON DARANG 331 DARLINGTON TRANSISTOR



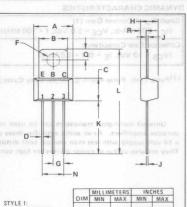
## MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub> (1)	40	Vdc
Collector-Emitter Voltage	VCES	40	Vdc
Collector-Base Voltage	VCB	50	Vdc
Emitter-Base Voltage	VEB	10	Vdc
Collector Current -Continuous	1 <sub>C</sub>	2.0	Adc
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1.0 8.0	Watt mW/ <sup>O</sup> C
Total Power Dissipation @ T <sub>C</sub> = 25 <sup>o</sup> C Derate above 25 <sup>o</sup> C	PD	10 80	Watts mW/ <sup>O</sup> C
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-55 to +150	C and

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA(2)	125	°C/W
Thermal Resistance, Junction to Case	R <sub>θJC</sub>	12.5	°C/W

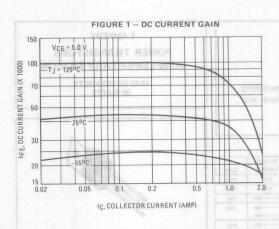
- (1) Due to the monolithic construction of this device, breakdown voltages of both transistor elements are identical. BV<sub>CES</sub> is tested in lieu of BV<sub>CEO</sub> in order to avoid errors caused by noise pickup. The voltage measured during the BV<sub>CES</sub> test is the BV<sub>CEO</sub> of the output transistor.
- (2)  $R_{ heta JA}$  is measured with the device soldered into a typical printed circuit board.

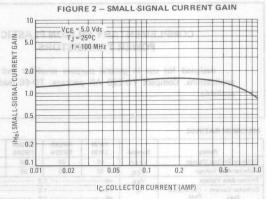


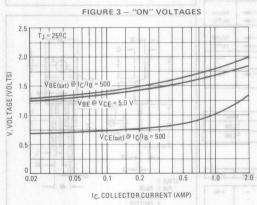
		MILLI	METERS	INC	HES
LE 1:	DIM	MIN	MAX	MIN	MAX
IN 1. EMITTER	A	9.14	9.53	0.360	0.375
2. BASE	В	6.60	7.24	0.260	0.285
3. COLLECTOR	C	5.41	5.66	0.213	0.223
	D	0.38	0.53	0.015	0.021
	F	3.18	3.33	0.125	0.131
	G	2.54 BSC		0.100 BSC	
	H	3.94	4.19	0.155	0.165
	J	0.36	0.41	0.014	0.018
	K	12.07	12.70	0.475	0.500
	L	25.02	25.53	0.985	1.005
	N	5.08	BSC	0.20	BSC
	0	2.39	2.69	0.094	0.106
	R	1.14	1.40	0.045	0.059

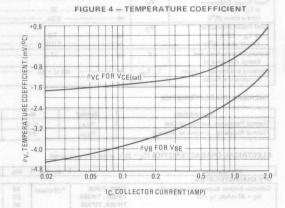


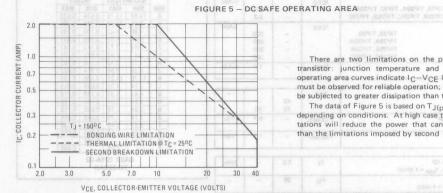
Characteristic		Symb	ol	Min	Тур	Max	Unit	
FF CHARACTERISTICS								
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 100 µAdc, V <sub>BE</sub> = 0)		BVCE	S	40	AMPLIFI	-	Vdc	
Collector-Base Breakdown Voltage (I <sub>C</sub> = 100 µAdc, I <sub>E</sub> = 0)		BVCB		50	ems not bar	elesio	Vdc	
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 10 µAdc, I <sub>C</sub> = 0)		BVEB	10	10	C Current 6	High C	Vdc	
Collector Cutoff Current (V <sub>CB</sub> = 30 Vdc, I <sub>E</sub> = 0)		ICBO	500	= al @ (nit)	19,000	100	nAdc	
Emitter Cutoff Current (VEB = 8.0 Vdc, I <sub>C</sub> = 0)		IEBO		( Wint) © 1	068 = 40 A	100	nAdc	
N CHARACTERISTICS(1)		598310	1 0 A	- of 60 abV	6.f = (sec)	o Wood *		
DC Current Gain  ( $I_C = 200 \text{ mAdc}$ , $V_{CE} = 5.0 \text{ Vdc}$ )  ( $I_C = 500 \text{ mAdc}$ , $V_{CE} = 5.0 \text{ Vdc}$ )  ( $I_C = 1.0 \text{ Adc}$ , $V_{CE} = 5.0 \text{ Vdc}$ )		hFE	oh Ri	25,000 15,000 4,000	43,000 41,000 35,000	150,000	-	
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)		VCE (sa	at)		1.0	1.5	Vdc	
Base-Emitter Saturation Voltage (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 2.0 mAdc)		V <sub>BE</sub> (sa	at)	-	1.85	2.0	Vdc	
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 5.0 Vdc)		V <sub>BE</sub> (o	n)	1	1.7	2.0	Vdc	
YNAMIC CHARACTERISTICS						20101101	Inches N. A.	
Small-Signal Current Gain (1) (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 5.0 Vdc, f = 100 MHz)	Vdc	h <sub>fe</sub>	(11)0	0.5	1.6	spelloV rettu	ollector-Er	
Collector Base Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	Vdc	C <sub>cb</sub>	8	y -	2.5	908 12 808 10 V 6	pF ad-rotadio	
1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0	1%. 55A							
HI LINE	Watt OWW	0.1						
Uniwatt darlington transistors can be used in any purpose amplifiers. As an audio amplifier these devic a 14 volt supply with less than one per cent distortion They are also useful as power drivers for high current	es, when used . Because of t	as a complem he high gain th	entary ie base	pair, can dri drive require	ve 3.5 watts i	nto a 3.2 ohm as 1 mA in th	speaker us	
	rinti			Sym				
STYLE II. SHITTER A S.18 SAT BASS DATE								











There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

# COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

... designed for use in general purpose amplifier and switching applications. Compact TO-220 AB package. TO-66 leadform also available.

### MAXIMUM RATINGS

Rating	Symbol	TIP29 TIP30	TIP29A TIP30A	TIP29B TIP30B	TIP29C TIP30C	Unit
Collector-Emitter Voltage	VCEO	40	60	80	100	Vdc
Collector-Base Voltage	VCB	40	60	80	100	Vdc
Emitter-Base Voltage	VEB	4	5	.0 —	-	Vdc
Collector Current - Continuous - Peak Peak	¹c	1.0				
Base Current	1 <sub>B</sub>	4	0	.4	-	Adc
Total Power Dissipation  © T <sub>C</sub> = 25°C  Derate above 25°C	PD YAS SM	30 0.24				
Total Power Dissipation  © T <sub>A</sub> = 25°C  Derate above 25°C	PD	2.0				Watts W/ <sup>O</sup> C
Unclamped Inductive Load Energy (See Note 3)	E	-	3	2		mJ
Operating and Storage Junction Temperature Range	TJ, Tstg	gav RDA g	-65 to	+150	-	°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	4.167	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS	20.0			30.1
Collector-Emitter Sustaining Voltage (1) TIP29, TIP30 (IC = 30 mAdc, I <sub>B</sub> = 0) TIP29A, TIP30A TIP29B, TIP30B TIP29C, TIP30C	VCEO(sus)	40 60 80 100	-	Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0) (VCE = 60 Vdc, IB = 0) TIP29, TIP29A, TIP30, TIP30A TIP29B, TIP29C, TIP30B, TIP30C	CEO	13%) 3	0.3	mAdd
Collector Cutoff Current (VCE = 40 Vdc, VEB = 0) TIP29, TIP30 (VCE = 60 Vdc, VEB = 0) TIP29A, TIP30A (VCE = 80 Vdc, VEB = 0) TIP29B, TIP30B (VCE = 100 Vdc, VEB = 0) TIP29C, TIP30B	ICES		200 200 200 200	μAdd
Emitter Cutoff Current (VBE = 5.0 Vdc, I <sub>C</sub> = 0)	IEBO	5 -	1.0	mAde
ON CHARACTERISTICS (1)	ando an assu	0		
DC Current Gain (I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	serohFE a e	40 15	- 75	1
Collector-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 125 mAdc)	VCE(sat)	0 -	0.7	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	V <sub>BE(on)</sub>	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (2) (I <sub>C</sub> = 200 mAdc, V <sub>CE</sub> = 10 Vdc, f <sub>test</sub> = 1 MHz)	fT	3.0	1	MHz
Small-Signal Current Gain (IC = 0.2 Adc, VCE = 10 Vdc, f = 1 kHz)	h <sub>fe</sub>	20	-	-

(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2.0%.

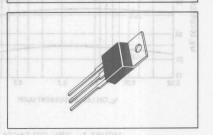
(2) fT = Ihfe | e ftest

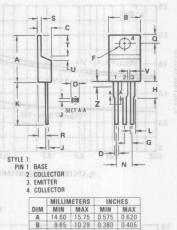
(3) This rating based on testing with  $L_C$  = 20 mH,  $R_{BE}$  = 100  $\Omega$ ,  $V_{CC}$  = 10 V,  $I_C$  = 1.8 A, P.R.F. = 10 Hz.

## 1 AMPERE

# POWER TRANSISTORS COMPLEMENTARY SILICON

40-60-80-100 VOLTS 30 WATTS

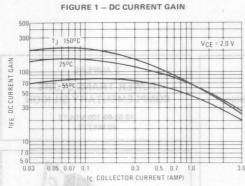


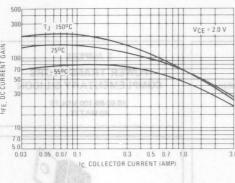


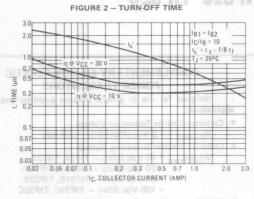
	MILLIN	ETERS	INCHES		
IM	MIN	MAX	MIN	MAX	
A	14.60	15.75	0.575	0.620	
В	9.65	10.29	0.380	0.405	
C	4.06	4.82	0.160	0.190	
D	0.64	0.89	0.025	0.035	
F	3.61	3.73	0.142	0.147	
G	2.41	2.67	0.095	0.105	
H	2.79	3.93	0.110	0.155	
J	0.36	0.56	0.014	0.022	
K	12.70	14.27	0.500	0.562	
L	1.14	1.39	0.045	0.055	
N	4.83	5.33	0.190	0.210	
Q	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	
T	5.97	6.48	0.235	0.255	
U	0.00	1.27	0.000	0.050	
V	1.14	1.724	0.045	-	
Z	west wi	2.03	0.50	0.080	
		ASE 22 TO-220		3.0	

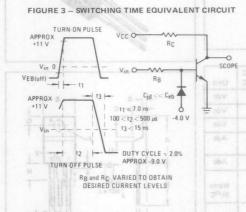
## TIP29, TIP29A, TIP29B, TIP29C, NPN, TIP30, TIP30A, TIP30B, TIP30C, PNP

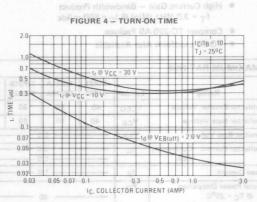


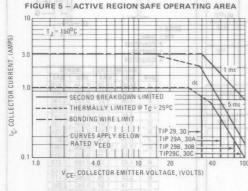












There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> operation; i.e., the transistor must not be subjected to greater dissipation than the

The data of Figure 5 is based on  $T_{J(pk)} = 150^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(p\,k)} \leqslant$  150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.



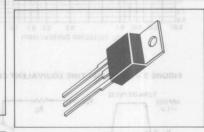
## COMPLEMENTARY SILICON PLASTIC POWER TRANSISTORS

- . . designed for use in general purpose amplifier and switching applications.
- Collector-Emitter Saturation Voltage
  - VCE(sat) = 1.2 Vdc (Max) @ IC = 3.0 Adc
- Collector-Emitter Sustaining Voltage
  - V<sub>CEO(sus)</sub> = 40 Vdc (Min) TIP31, TIP 32 = 60 Vdc (Min) TIP31A, TIP32A
    - = 60 Vdc (Min) TIP318, TIP328

      - = 100 Vdc (Min) TIP31C, TIP32C
- High Current Gain Bandwidth Product f<sub>T</sub> = 3.0 MHz (Min) @ I<sub>C</sub> = 500 mAdc
- Compact TO-220 AB Package
- TO-66 Leadform Also Available

## 3 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

40-60-80-100 VOLTS 40 WATTS



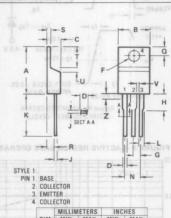
#### \*MAXIMUM RATINGS

Rating	Symbol	TIP31 TIP32	TIP31A TIP32A	TIP31B TIP32B	TIP31C TIP32C	Unit
Collector-Emitter Voltage	VCEO	40	60	80	100	Vdc
Collector-Base Voltage	VCB	40	60	80	100	Vdc
Emitter-Base Voltage	VEB	-	5.	0	-	Vdc
Collector Current - Continuous Peak	lc	=		Adc		
Base Current	IB	-	1.	0	-	Adc
Total Power Dissipation  © T <sub>C</sub> = 25 <sup>o</sup> C  Derate above 25 <sup>o</sup> C	PD	u.pg.51	40			
Total Power Dissipation  @ T <sub>A</sub> = 25°C  Derate above 25°C	PD	2.0				Watts W/OC
Unclamped Inductive Load Energy (1)	E	32				mJ
Operating and Storage Junction Temperature Range	5 519	no lonu	— -65 to	+150 —		°C

#### THERMAL CHARACTERISTICS

Characteristic Tana Sanda A	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	3.125	°C/W
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W

(1)  $I_C = 1.8 \text{ A}$ , L = 20 mH, P.R.F. = 10 Hz,  $V_{CC} = 10 \text{ V}$ ,  $R_{BE} = 100 \Omega$ .



	MILLIN	ETERS	INC	HES
MIC	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

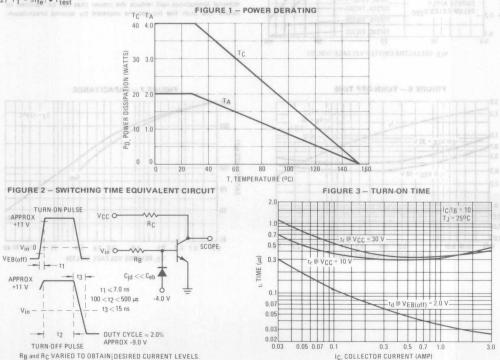
CASE 221A-02 TO-220AB

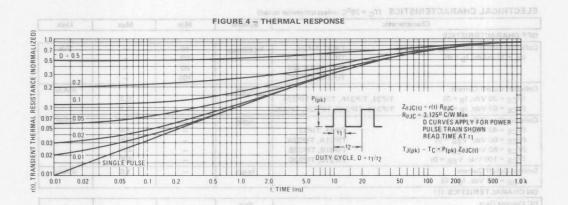
## TIP31, TIP31A, TIP31B, TIP31C, NPN, TIP32, TIP32A, TIP32B, TIP32C, PNP

Characteristic	Symbol	Min	Max	Unit	
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	VCEO(sus)	40 60 80 100	1	Vdc
02	, TIP31A, TIP32, TIP32A B, TIP31C, TIP32B, TIP32C	ICEO		0.3 0.3	mAdc
Collector Cutoff Current (VCE = 40 Vdc; VEB = 0) (VCE = 60 Vdc; VEB = 0) (VCE = 80 Vdc; VEB = 0) (VCE = 100 Vdc; VEB = 0)	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	ICES		200 200 200 200 200	μAdc S0 0
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	50 10 20	IEBO	0 5.0	1.0 T.0 20.0	mAdc m
ON CHARACTERISTICS (1)	(AN) SINT				
DC Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	DRA DINITAD SED 22 AD MO	hFE	25 10	- 50	_
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 375 mAdc)		VCE(sat)		1.2	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc)		V <sub>BE(on)</sub>	7-	1.8	Vdc
DYNAMIC CHARACTERISTICS	to econovo notriborati	1,435	/ an 0.1	mili 2 - 1 - 2 - 1 mili	
Current Gain — Bandwidth Product (2) (IC = 500 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 1 M	So sers printering site?	fT	3.0	WOON A SET VILAT	MHz
Small-Signal Current Gain (IC = 0.5 Adc, VCE = 10 Vdc, f = 1 kHz)	a bez signe ad san reuni	Ihfel	20	DIRT J - 1979C AL LIMIT R Tg - 259	STERRE -

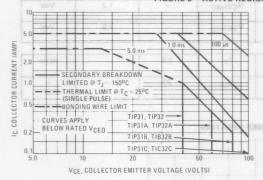








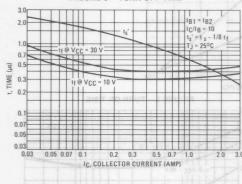
#### FIGURE 5 - ACTIVE REGION SAFE OPERATING AREA



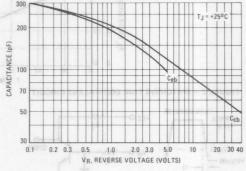
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on T<sub>J(pk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided T  $_{J(pk)} \le 150^{o}$ C. T  $_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

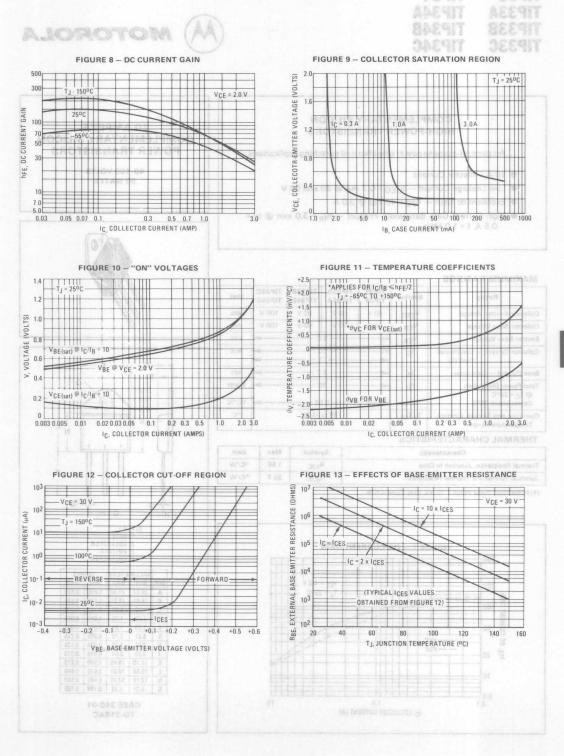




# FIGURE 7 - CAPACITANCE



## TIP31, TIP31A, TIP31B, TIP31C, NPN, TIP32, TIP32A, TIP32B, TIP32C, PNP





## **COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS**

... for general-purpose power amplifier and switching applications.

- 10 A Collector Current
- Low Leakage Current I<sub>CEO</sub> = 0.7 mA @ 30 and 60 V
- Excellent dc Gain hFE = 40 Typ @ 3.0 A
- High Current Gain Bandwidth Product hfe = 3.0 min @ IC = 0.5 A, f = 1.0 MHz

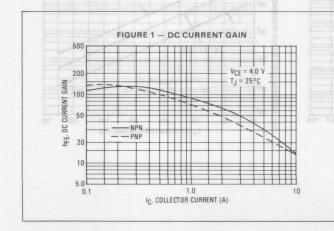
## MAXIMUM RATINGS

Rating	Symbol	TIP33 TIP34	TIP33A TIP34A	TIP33B TIP34B	TIP33C TIP34C	Unit
Collector-Emitter Voltage	VCEO	40 V	60 V	80 V	100 V	Vdc
Collector-Base Voltage	Vcв	40 V	60 V	80 V	100 V	Vdc
Emitter-Base Voltage	VEB	5.0				Vdc
Collector Current — Continuous Peak (1)	lc	10				Adc
Base Current — Continous	IB	3.0				Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C	PD	80				Watts
Derate above 25°C		- NO.	0.	64 —	-	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150				°C

## THERMAL CHARACTERISTICS

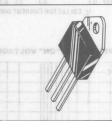
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.56	°C/W
Junction-To-Free-Air Thermal Resistance	R <sub>θ</sub> JA	35.7	°C/W

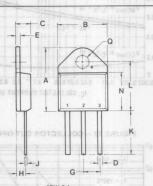
(1) Pulse Test: Pulse Width = 10 ms, Duty Cycle ≤10%



## 10 AMPERE **COMPLEMENTARY SILICON POWER TRANSISTORS**

40-100 VOLTS 80 WATTS





STYLE 1: 1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR

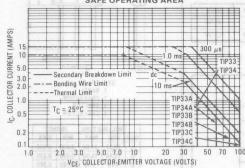
	MILLLIN	IE LEHS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	20.32	21.08	0.800	0.830	
В	15.49	15.90	0.610	0.626	
C	4.19	5.08	0.165	0.200	
D	1.02	1.65	0.040	0.065	
E	1.35	1.65	0.053	0.065	
G	5.21	5.72	0.205	0.225	
H	2.41	3.20	0.095	0.126	
J	0.38	0.64	0.015	0.025	
K	12.70	15.49	0.500	0.610	
L	15.88	16.51	0.625	0.650	
N	12.19	12.70	0.480	0.500	
Q	4.04	4.22	0.159	0.166	

CASE 340-01 TO-218AC

TIP33, TIP33A, TIP33B, TIP33C, TIP34, TIP34A, TIP34B, TIP34C

Characteristic			Symbol	Min		10.1	Max	Unit
OFF CHARACTERISTICS								
atiov oor-oa	TIP33, TIP TIP33A, T TIP33B, TI TIP33C, TI	IP34A P34B	BVCEO	40 60 80	vier - let	Inen	nu <mark>O</mark> noton	DV gener
Collector-Emitter Cutoff Current (VCE = 30 V, I <sub>B</sub> = 0) TIP33, TIP33A, TIP34B, TIP34B, TIP33B, TIP33B, TIP33C,			ICEO A P	-			0.7	Am ellent     D High Car
Collector-Emitter Cutoff Current (VCE = Rated VCEO, VEB = 0)			ICES	-		33	0.4	mA
Emitter-Base Cutoff Current (V <sub>EB</sub> = 5.0 V, I <sub>C</sub> = 0)			IEBO	-			1.0	mA
ON CHARACTERISTICS (1)		7.11		3.41.5.7			SOM	TAR MUMIXA
DC Current Gain (I <sub>C</sub> = 1.0 A, V <sub>CE</sub> = 4.0 V) (I <sub>C</sub> = 3.0 A, V <sub>CE</sub> = 4.0 V)	nau	8 11835C 8 14936C	acuit Aecsi	40 20	loon	sy8	_ 100	Rating
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 A, I <sub>B</sub> = 0.3 A) (I <sub>C</sub> = 10 A, I <sub>B</sub> = 2.5 A)	obV Vdc	V 001	VCE(sat)	V 03	91	V	1.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 3.0 A, V <sub>CE</sub> = 4.0 V) (I <sub>C</sub> = 10 A, V <sub>CE</sub> = 4.0 V)	phA	4	V <sub>BE(on)</sub>	- 10			1.6	Vdc mag
DYNAMIC CHARACTERISTICS					1 1			
Small-Signal Current Gain (I <sub>C</sub> = 0.5 A, V <sub>CE</sub> = 10 V, f = 1.0 kHz)	271.00		h <sub>fe</sub>	20	. 0		-	Tg = 25°C care above 25°C
Current-Gain—Bandwidth Product (2) (I <sub>C</sub> = 0.5 A, V <sub>CE</sub> = 10 V, f = 1.0 MHz)	3.		oer-ftree-	3.0	use	et.	nonsnut	A ALL
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0 (2) f <sub>T</sub> = [h <sub>fe</sub> ] · f <sub>test</sub>	)%.		08		88	d	bac	nnerature Range.  Import Inductive Co

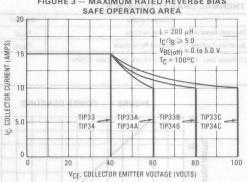
#### FIGURE 2 - MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA



#### **FORWARD BIAS**

The Forward Bias Safe Operating Area represents the voltage and current conditions these devices can withstand during forward bias. The data is based on TC = 25°C; T<sub>J(pk)</sub> is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10%, and must be derated thermally for  $T_{\text{C}} > 25 \,^{\circ}\text{C}$ .

#### FIGURE 3 - MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



#### **REVERSE BIAS**

The Reverse Bias Safe Operating Area represents the voltage and current conditions these devices can withstand during reverse biased turn-off. This rating is verified under clamped conditions so the device is never subjected to an avalanche mode.

#### **COMPLEMENTARY SILICON** HIGH-POWER TRANSISTORS

... for general-purpose power amplifier and switching applications.

- 25 A Collector Current
- $\bullet$  Low Leakage Current I<sub>CEO</sub> = 1.0 mA @ 30 and 60 V
- Excellent dc Gain hFE = 40 Typ @ 15 A
- High Current Gain Bandwidth Product (hfe = 3.0 min @ IC = 3.0 1.0 A, f = 1.0 MHz

## 25 AMPERE **COMPLEMENTARY SILICON POWER TRANSISTORS**

40-100 VOLTS 125 WATTS

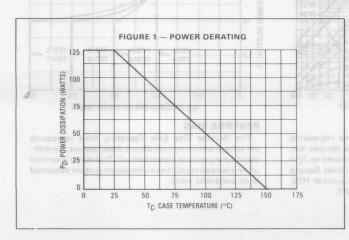
#### **MAXIMUM RATINGS**

Rating	Symbol	TIP35 TIP36	TIP35A TIP36A	TIP35B TIP36B	TIP35C TIP36C	Unit
Collector-Emitter Voltage	VCEO	40 V	60 V	80 V	100 V	Vdc
Collector-Base Voltage	V <sub>CB</sub>	40 V	60 V	80 V	100 V	Vdc
Emitter-Base Voltage	V <sub>EB</sub>	4	5	.0	>	Vdc
Collector Current — Continuous Peak (1)	<sup>I</sup> C	4	25 40			Adc
Base Current — Continous	I <sub>B</sub>	5.0		>	Adc	
Total Power Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	200		.0 —	> >	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150			°C	
Unclamped Inductive Load	ESB		9	10		mJ

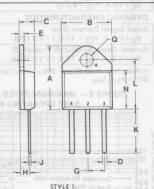
## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.0	°C/W
Junction-To-Free-Air Thermal Resistance	R <sub>θ</sub> JA	35.7	°C/W

(1) Pulse Test: Pulse Width = 10 ms, Duty Cycle ≤ 10%.







1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

	MILLIMETERS		INC	HES
DIM	DIM MIN MAX		MIN	MAX
A	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
DL:	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

ions the

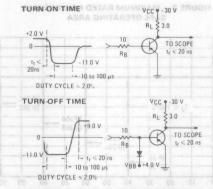
CASE 340-01 TO-218AC

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS	500	3085 - 17 - 2800		M4h	1 107
Collector-Emitter Sustaining Voltage (1) $(I_C = 30 \text{ mA}, I_B = 0)$	TIP35, TIP36 TIP35A, TIP36A TIP35B, TIP36B TIP35C, TIP36C	BVCEO	40 60 80 100		Vdc 0.5
CL	A, TIP36, TIP36A 5C, TIP36B, TIP36C	ICEO		1.0	mA an
Collector-Emitter Cutoff Current (VCE = Rated VCEO, VEB = 0)	2.0	ICES		0.7	mA: n
Emitter-Base Cutoff Current (VEB = 5.0 V, IC = 0)	1.0	IEBO	3,0 5.0	1.0	mA mA
ON CHARACTERISTICS (1)		120	DURRENT INSPEC	SOLUEGIOS 31	
DC Current Gain (I <sub>C</sub> = 1.5 A, V <sub>CE</sub> = 4.0 V) (I <sub>C</sub> = 15 A, V <sub>CE</sub> = 4.0 V)	FIGURE 6	hFE	25 15	- 75 <sub>2 A I</sub> S	ORWARD
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 15 A, I <sub>B</sub> = 1.5 A) (I <sub>C</sub> = 25 A, I <sub>B</sub> = 5.0 A)	ny na mana (101	bnoose und second	on the power has no temperate and the second	enoilstimil or	This Vdc if
Base-Emitter On Voltage (I <sub>C</sub> = 15 A, V <sub>CE</sub> = 4.0 V) (I <sub>C</sub> = 25 A, V <sub>CE</sub> = 4.0 V)	Oe OB OK SE	subjected to	nust be observed be d must not be duryes indical	ntaian2.0 adj	peration, i.e.
DYNAMIC CHARACTERISTICS	01 2		sed on T <sub>C</sub> = 2		
Small-Signal Current Gain (I <sub>C</sub> = 1.0 A, V <sub>CE</sub> = 10 V, f = 1.0 kHz)	E Bit Hard	hfe	25 01 of caloya y	ding on power exists for dust	ulse limits ar
Current-Gain—Bandwidth Product (2) (I <sub>C</sub> = 1.0 A, V <sub>CE</sub> = 10 V, f = 1.0 MHz)	018	fT su	3.0	he same as the	MHz

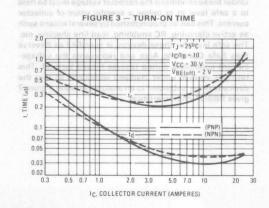
FIGURE 2 — SWITCHING TIME EQUIVALENT TEST CIRCUITS

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤2.0%.

(2) f<sub>T</sub> = [h<sub>fe</sub>] · f<sub>test</sub>



FOR CURVES OF FIGURES 3 & 4,  $R_{\rm B}$  &  $R_{\rm L}$  ARE VARIED. INPUT LEVELS ARE APPROXIMATELY AS SHOWN. FOR NPN, REVERSE ALL POLARITIES.



REVERSE BIAS

# 3

FIGURE 4 - TURN-OFF TIME

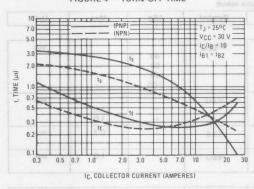
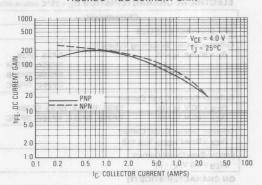


FIGURE 5 - DC CURRENT GAIN

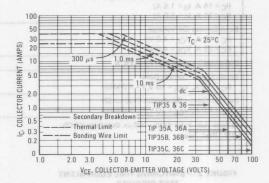


## FORWARD BIAS

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate IC-VCE limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on  $T_C=25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \! \ge \! 25^{\circ}C$ . Second breakdown limitations do not derate the same as thermal limitations.

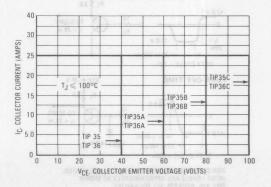
## FIGURE 6 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA



#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 7 gives RBSOA characteristics.

FIGURE 7 — MAXIMUM RATED REVERSE BIAS SAFE OPERATING AREA



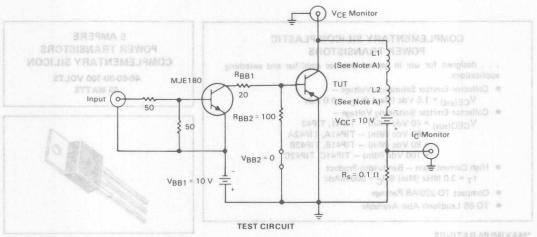
# 3

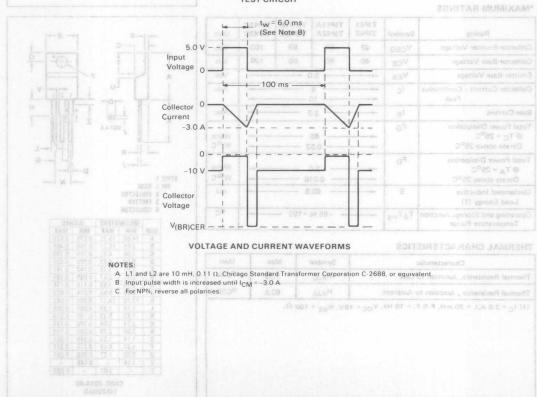
## TIP35, TIP35A, TIP35B, TIP35C, NPN, TIP36, TIP36A, TIP36B, TIP36C, PNP



TIP41 TIP42 TIP41A TIP42A TIP41B TIP42B TIP41C TIP42C

FIGURE 8 — INDUCTIVE LOAD SWITCHING





# TIP41C TIP42C



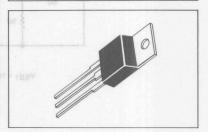
COMPLEMENTARY SILICON PLASTIC **POWER TRANSISTORS** 

. . . designed for use in general purpose amplifier and switching applications.

- Collector-Emitter Saturation Voltage —
- V<sub>CE(sat)</sub> = 1.5 Vdc (Max) @ I<sub>C</sub> = 6.0 Adc Collector-Emitter Sustaining Voltage —
- VCEO(sus) = 40 Vdc (Min) TIP41, TIP42 = 60 Vdc (Min) — TIP41A, TIP42A = 80 Vdc (Min) — TIP41B, TIP42B = 100 Vdc (Min) — TIP41C, TIP42C
- High Current Gain Bandwidth Product f<sub>T</sub> = 3.0 MHz (Min) @ I<sub>C</sub> = 500 mAdc
- Compact TO-220 AB Package
- TO-66 Leadform Also Available

## 6 AMPERE POWER TRANSISTORS **COMPLEMENTARY SILICON**

40-60-80-100 VOLTS 65 WATTS



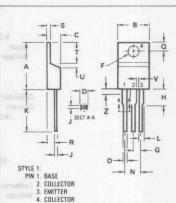
## \*MAXIMUM RATINGS

Rating	Symbol	TIP41 TIP42	TIP41A TIP42A	TIP41B TIP42B	TIP41C TIP42C	Unit
Collector-Emitter Voltage	VCEO	40	60	80	100	Vdc
Collector-Base Voltage	VCB	40	60	80	100	Vdc
Emitter-Base Voltage	VEB	-	5.	0	-	Vác
Collector Current - Continuous Peak	IC	6 10				Adc
Base Current	IB	- 1	- 2.	0 —	-	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25°C  Derate above 25°C	PD	65				Watts W/ <sup>O</sup> C
Total Power Dissipation  @ T <sub>A</sub> = 25°C  Derate above 25°C	PD		2.0			
Unclamped Inductive Load Energy (1)	E	62.5			mJ	
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>		-65 to	o +150 —		°C

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case 1880 Co.	R <sub>θ</sub> JC	1.92	oC/W
Thermal Resistance , Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

(1)  $I_C$  = 2.5 A,L = 20 mH, P.R.F. = 10 Hz,  $V_{CC}$  = 10V,  $R_{BE}$  = 100  $\Omega_{\star}$ 



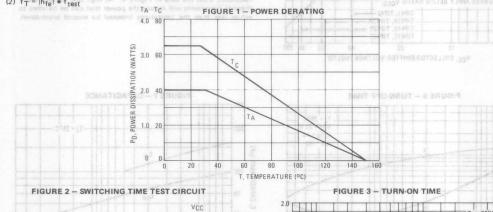
	MILLIN	ETERS	INC	HES
MIC	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.23	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
Н	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

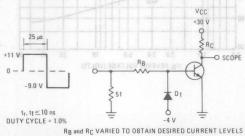
CASE 221A-02 TO-220AB

LYAGE AND CURRENT WAVEFORMS

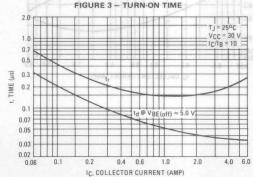
## TIP41, TIP41A, TIP41B, TIP41C, NPN, TIP42, TIP42A, TIP42B, TIP42C, PNP

Characteristic	HAL RESPONSE	Symbol	Min Min	Max	Unit
OFF CHARACTERISTICS					P
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	TIP41, TIP42 TIP41A, TIP42A TIP41B, TIP42B TIP41C, TIP42C	VCEO(sus)	40 60 80 100	<u> </u>	Vdc
	P41A, TIP42, TIP42A IP41C, TIP42B, TIP42C	ICEO		0.7 0.7	mAdc
Collector Cutoff Current (VCE = 40 Vdc, VEB = 0) (VCE = 60 Vdc, VEB = 0) (VCE = 80 Vdc, VEB = 0) (VCE = 100 Vdc, VEB = 0)	TIP41, TIP42 TIP41A, TIP42A TIP41B, TIP42B TIP41C, TIP42C	ICES		400 400 400 400	µАdс
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO		1.0	mAdc
ON CHARACTERISTICS (1)	bas 3MrT				
DC Current Gain (I <sub>C</sub> = 0.3 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc)		hFE	30 15	- 75	-
Collector-Emitter Saturation Voltage (IC = 6.0 Adc, IB = 600 mAdc)	SAFE OPERATING A	VCE(sat)	FIGURES 6 - A	1,5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 6.0 Adc, V <sub>CE</sub> = 4.0 Vdc)		VBE(on)	$X \vdash X$	2.0	Vdc
DYNAMIC CHARACTERISTICS	owt sie sient	TIPE X			
Current Gain - Bandwidth Product (2) (IC = 500 mAdc, VCE = 10 Vdc, f <sub>test</sub> = 1 MHz)		fT	3.0	J	MHz
Small-Signal Current Gain (IC = 0.5 Adc, VCE = 10 Vdc, f = 1 kHz)		Ihfel	20	NNO DREATONN C	1032





D1 MUST BE FAST RECOVERY TYPE, eg: MBD5300 USED ABOVE IB  $\approx$ 100 mA MSD6100 USED BELOW IB  $\approx$ 100 mA



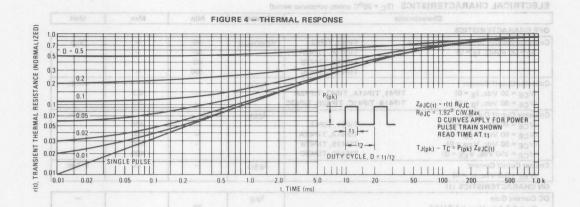
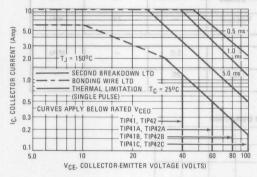
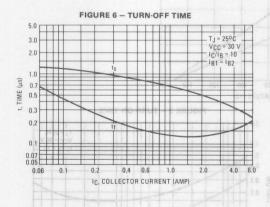


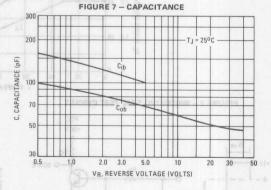
FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



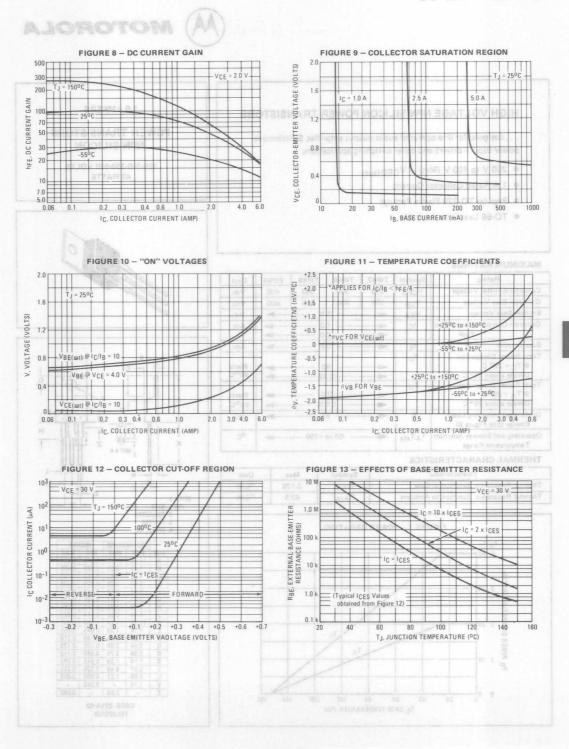
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}=150^{\circ}\mathrm{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leqslant 150^{\circ}\mathrm{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





## TIP41, TIP41A, TIP41B, TIP41C, NPN, TIP42, TIP42A, TIP42B, TIP42C, PNP





## HIGH VOLTAGE NPN SILICON POWER TRANSISTORS

. . . designed for line operated audio output amplifier, Switchmode power supply drivers and other switching applications.

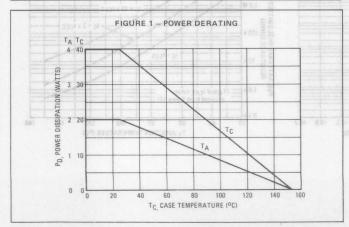
- 250 V to 400 V (Min) VCEO(sus)
- 1 A Rated Collector Current
- Popular TO-220 Plastic Package
- TO-66 Leadform Available

## MAXIMUM RATINGS 3 BRUTARS MET - 11 BRUDER

Rating	Symbol	TIP47	TIP48	TIP49	TIP50	Unit
Collector-Emitter Voltage	VCEO	250	300	350	400	Vdc
Collector-Base Voltage	VCB	350	400	450	500	Vdc
Emitter-Base Voltage	VEB	4	5	.0	-	Vdc
Collector Current - Continuous Peak	IC	4		.0	-	Adc
Base Current	1 <sub>B</sub>	4	0	.6	-	Adc
Total Power Dissipation  @ T <sub>C</sub> = 25° C  Derate above 25° C	PD	4		10 ————————————————————————————————————	-	Watts W/OC
Total Power Dissipation  @ T <sub>A</sub> = 25° C  Derate above 25° C	PD	B VBE		.0 ——	=	Watts W/OC
Unclamped Inducting Load Energy (See Figure 8)	a.E	p ₹10	77 2	20	-0.0	mJ
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	4	65 to	o +150 —	-	°C

## THERMAL CHARACTERISTICS

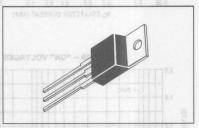
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

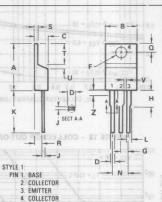


## 1.0 AMPERE

# POWER TRANSISTORS NPN SILICON

250-300-350-400 VOLTS 40 WATTS





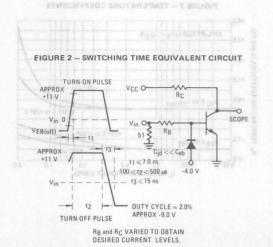
	MILLIM	ETERS	INC	HES
MID	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
1	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
٧	1.14	-	0.045	-
Z	-	2.03	-	0.080

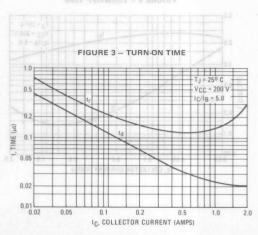
TO-220AB

3

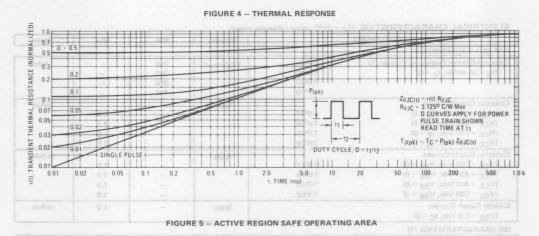
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					20 S
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	TIP47 TIP48 TIP49 TIP50	VCEO(sus)	250 300 350	- sı	Vdc
O H C C C C C C C C C C C C C C C C C C	11750		400		- 8
Collector Cu toff Current  (VCE = 150 Vdc, I <sub>B</sub> = 0)  (VCE = 200 Vdc, I <sub>B</sub> = 0)  (VCE = 250 Vdc, I <sub>B</sub> = 0)  (VCE = 300 Vdc, I <sub>B</sub> = 0)	TIP47 TIP48 TIP49 TIP50	CEO		1.0 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V <sub>CE</sub> = 350 Vdc, V <sub>BE</sub> = 0)	TIP47	ICES		1.0	mAdc
(V <sub>CE</sub> = 400 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 450 Vdc, V <sub>BE</sub> = 0) (V <sub>CE</sub> = 500 Vdc, V <sub>BE</sub> = 0)	TIP48 TIP49 TIP50	90 80	- CO _ CO	1.0 1.0	
Emitter Cutoff Current (V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		IEBO	-	1.0	mAdc
ON CHARACTERISTICS (1)	MIARSTU STAG NOTUS	N BALLAN - C S	MUDIS		
DC Current Gain (IC = 0.3 Adc, VCE = 10 Vdc) (IC = 1.0 Adc, VCE = 10 Vdc)	There are to	hFE	30 10	150	1 0.0
Collector-Emitter Saturation Voltage (IC = 1.0 Adc, IB = 0.2 Adc)		VCE (sat)		1.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 Vdc)	dus effect team	V <sub>BE</sub> (on)	A DATINI L'ENGO	1.5	Vdc
DYNAMIC CHARACTERISTICS	depending on c	11/	ED @ 289 C	TIME I YELAMRERT -	
Current Gain — Bandwidth Product (IC = 0.2 Adc, VCE = 10 Vdc, f = 2.0 MHz)	ter duty cycles calculated from	fr	10	WU JEW <u>S</u> WIGWORI-	MHz
Small-Signal Current Gain (IC = 0.2 Adc, VCF = 10 Vdc, f = 1.0 kHz)	values less than	hfe	25	-03aV Ga	A8 50.0

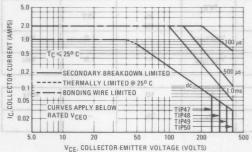
(1) Pulse Test: Pulsewidth ≤ 300 µs, Duty Cycle ≤ 2.0%.





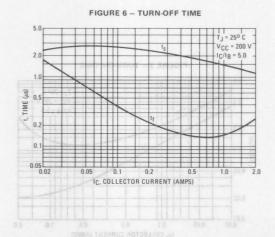


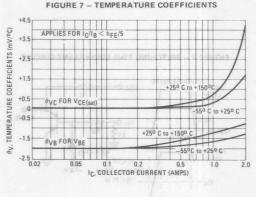




There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_{\mbox{\scriptsize CVCE}}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

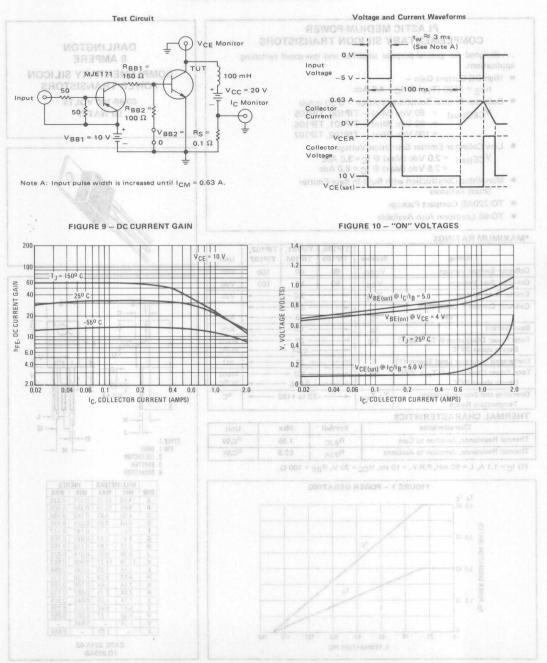
The data of Figure 5 is based on  $T_{J(pk)}=150^{o}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \approx 150^{o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.







#### FIGURE 8 - INDUCTIVE LOAD SWITCHING



## NPN PNP **TIP100 TIP105 TIP101 TIP106 TIP102 TIP107**

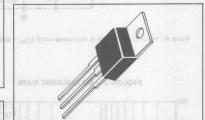


## PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

... designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain
  - hFE = 2500 (Typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 30 mAdc
   VCEO(sus) = 60 Vdc (Min) TIP100, TIP105
   80 Vdc (Min) TIP101, TIP106
  - = 100 Vdc (Min) TIP102, TIP107
- Low Collector-Emitter Saturation Voltage
- V<sub>CE</sub>(sat) = 2.0 Vdc (Max) @ I<sub>C</sub> = 3.0 Adc = 2.5 Vdc (Max) @ I<sub>C</sub> = 8.0 Adc Monolithic Construction with Built-In Base-Emitter
- Shunt Resistors
- TO-220AB Compact Package
- TO-66 Leadform Also Available

## DARLINGTON 8 AMPERE **COMPLEMENTARY SILICON POWER TRANSISTORS** 60-80-100 VOLTS 80 WATTS

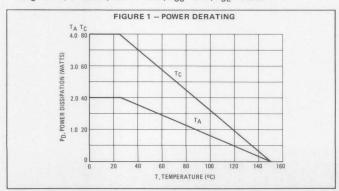


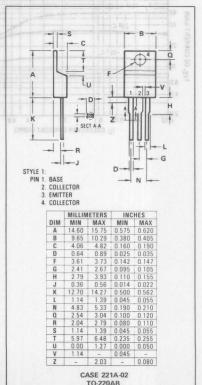
#### \*MAXIMIM BATINGS

Rating	Symbol	TIP100, TIP105	TIP101, TIP106	TIP102, TIP107	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	-	— 5.0 —	-	Vdc
Collector Current - Continuous Peak	I C	1	— 8.0 — — 15 —		Adc
Base Current	IB	-	— 1.0 —	-	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD		— 80 — — 0.64 —		Watts W/OC
Unclamped Inductive Load Energy (1)	E	-	— 30 —	-	mJ
Total Power Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	PD	1	— 2.0 — — 0.016 –		Watts W/OC
Operating and Storage Junction	T <sub>J</sub> , T <sub>stg</sub>	-	-65 to +15	0	°C

THERMAL CHARACTERISTICS					
Characteristics	Symbol	Max	Unit		
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.56	°C/W		
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W		

(1) I\_C = 1.1 A, L = 50 mH, P.R.F. = 10 Hz, V\_{CC} = 20 V, R\_{BE} = 100  $\Omega$ .





## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					3
Collector-Emitter Sustaining Voltage (1)		VCEO(sus)			Vdc.
(I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	TIP100, TIP105		60		
20,000 - 100 House	TIP101, TIP106		80		-1121-1
	TIP102, TIP107		100		30 1
Collector Cutoff Current		ICEO	1	HHADE	μAdc
(V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)	TIP100, TIP105		1 1	50	10.8
(V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)	TIP101, TIP106		+ $+$ $+$ $-$	50	1
(V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)	TIP102, TIP107		++-	50	Ting President
Collector Cuttoff Current		Ісво		- SIMPLE LATER	μAdc
(V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)	TIP100, TIP105			50	L_Day
(V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	TIP101, TIP106	0.5 0.0	- 9	50	50.0 10.0
(V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)	TIP102, TIP107			50	
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)		IEBO	-	8.0	mAdc

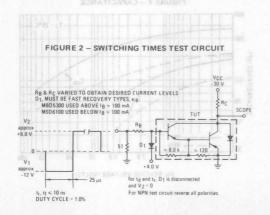
## ON-CHARACTERISTICS (1)

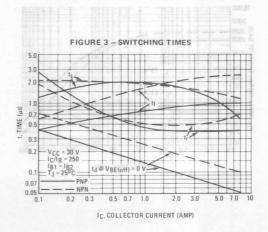
DC Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	hFE	1000	20,000	Z = 01 0.
Collector-Emitter Saturation Voltage $(I_C = 3.0 \text{ Adc}, I_B = 6.0 \text{ mAdc})$ $(I_C = 8.0 \text{ Adc}, I_B = 80 \text{ mAdc})$	VCE(sat)	26   1   1	2.0 2.5	Vdc <sub>0.5</sub>
Base-Emitter On Voltage (I <sub>C</sub> = 8.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	VBE(on)	0.00 T <sub>C</sub> = 200 0.00 UNITED	2.8	Vdc

## DYNAMIC CHARACTERISTICS

Small-Signal Current Gain (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 4.0 Vdc, f = 1.0 MHz)		4.0		
00	106, TIP107 101, TIP102	OS . OF	300 200	pF

(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2%.





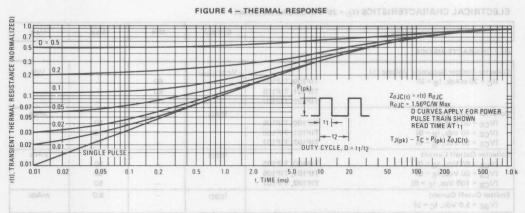
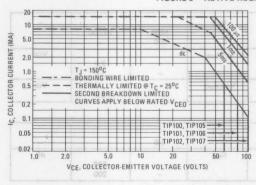
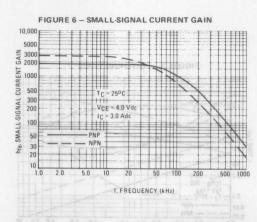


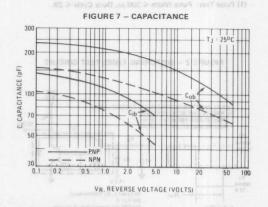
FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C = V_{CE}$  limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}=150^{o}C$ :  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}<150^{o}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown



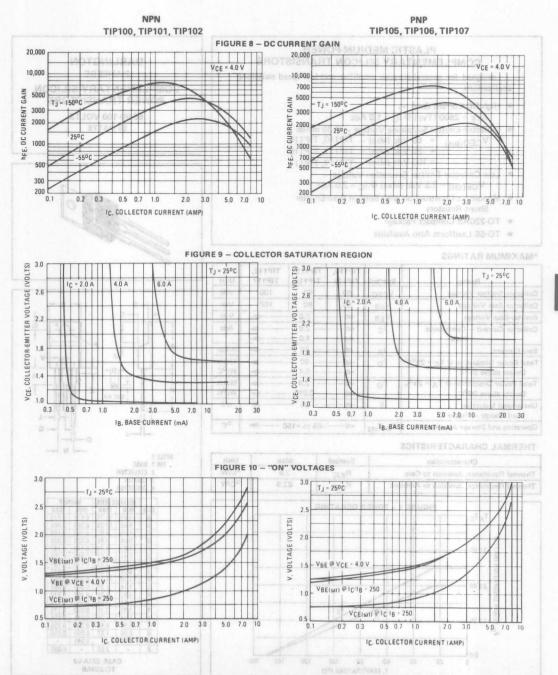


## 3

## TIP100, TIP101, TIP102 NPN/TIP105, TIP106, TIP107 PNP









# PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

 $\ldots$  designed for general-purpose amplifier and low-speed switching applications.

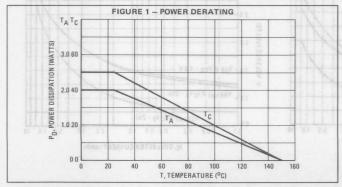
- High DC Current Gain
  - hFE = 2500 (Typ) @ IC = 1.0 Adc
- Collector-Emitter Sustaining Voltage @ 30 mAdc
   VCEO(sus) = 60 Vdc (Min) TIP110, TIP115
   = 80 Vdc (Min) TIP111, TIP116
  - = 80 Vdc (Min) TIP111, TIP116 = 100 Vdc (Min) — TIP112, TIP117
- Low Collector-Emitter Saturation Voltage –
   VCE(sat) = 2.5 Vdc (Max) @ IC = 2.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
- TO-220AB Compact Package
- TO-66 Leadform Also Available

## \*MAXIMUM RATINGS

Rating	Symbol	TIP110, TIP115	TIP111, TIP116	TIP112, TIP117	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB	4	5.0	-	Vdc
Collector Current — Continuous Peak	lc	<b>*</b>	2.0 4.0	-	Adc
Base Current	IB	-	<del></del>	-	mAdc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4	50 0.4		Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	1	2.0 0.016 -		Watts W/OC
Unclamped Inductive Load Energy — Figure 13	E	1.0 8.0	25		mJ
Operating and Storage Junction,	TJ, Tstg	4	-65 to +15	0	°C

#### THERMAL CHARACTERISTICS

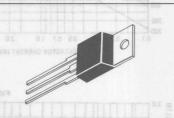
Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	2.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	°C/W

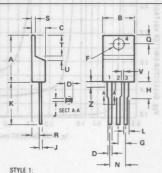


## DARLINGTON 2 AMPERE

## COMPLEMENTARY SILICON POWER TRANSISTORS

60-80-100 VOLTS 50 WATTS





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

	MILLIN	IETERS	INC	INCHES		
MIC	MIN	MAX	MIN	MAX		
A	14.60	15.75	0.575	0.620		
В	9.65	10.29	0.380	0.405		
C	4.06	4.82	0.160	0.190		
D	0.64	0.89	0.025	0.035		
F	3.61	3.73	0.142	0.147		
G	2.41	2.67	0.095	0.105		
H	2.79	3.93	0.110	0.155		
J	0.36	0.56	0.014	0.022		
K	12.70	14.27	0.500	0.562		
L	1.14	1.39	0.045	0.055		
N	4.83	5.33	0.190	0.210		
0	2.54	3.04	0.100	0.120		
R	2.04	2.79	0.080	0.110		
S	1.14	1.39	0.045	0.055		
T	5.97	6.48	0.235	0.255		
U	0.00	1.27	0.000	0.050		
٧	1.14	7.3	0.045	-		
Z	-	2.03	-	0.080		

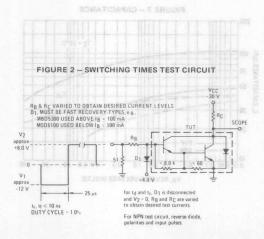
TO-220AB

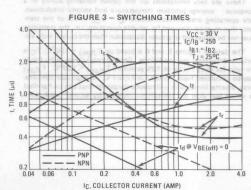
3

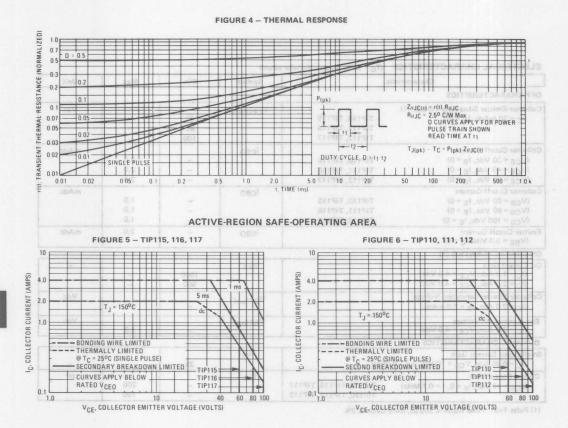
## TIP110, TIP111, TIP112, NPN, TIP115, TIP116, TIP117, PNP 917, TIP117, OFF917

Characteristi	ic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					10
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	TIP110, TIP115 TIP111, TIP116 TIP112, TIP117	VCEO(sus)	60 80 100		Vdc
Collector Cutoff Current (VCE = 30 Vdc, IB = 0) (VCE = 40 Vdc, IB = 0) (VCE = 50 Vdc, IB = 0)	TIP110, TIP115 TIP111, TIP116 TIP112, TIP117	ICEO		2.0 2.0 2.0	mAdc so
Collector Cutoff Current (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)	TIP110, TIP115 TIP111, TIP116 TIP112, TIP117	СВО	- - - XCTIVI	1.0 1.0 1.0	mAdc
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)	FIGURE	IEBO	5, 116, 117	2.0 1917 – 8 anus	mAdc
ON CHARACTERISTICS (1)	F 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	EHER-I-		BUTTO	
DC Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	(3 )	hFE	1000 500		
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 2.0 Adc, I <sub>B</sub> = 8.0 mAdc)	100 8	VCE(sat)		2.5	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 2.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	01 8	V <sub>BE(on)</sub>		2.8	Vdc
DYNAMIC CHARACTERISTICS	En w amound al			DETING TRIVE	11011016
Small-Signal Current Gain (I <sub>C</sub> = 0.75 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0	MHz)	h <sub>fe</sub>	25	LLCY LINGERS TO SINGLE PULSE NEY BRIGAKDOWN	MR387
Output Capacitance (VCB = 10 Vdc, IE = 0, f = 0.1 MHz)	TIP115, TIP116, TIP117 TIP110, TIP111, TIP112	C <sub>ob</sub>	arian-		SVRUS PF 931AR

(1) Pulse Test: Pulse Width  $\leq$  300  $\mu$ s, Duty Cycle  $\leq$  2%.

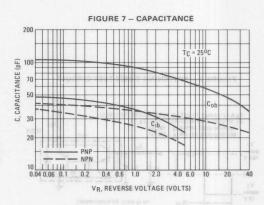






There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on  $T_{J(pk)}=150^{\circ}\text{C}$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)}<150^{\circ}\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.





## PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

... designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain
  - $h_{FE} = 2500 \text{ (Typ)} @ I_{C} = 3.0 \text{ Adc}$
- Collector-Emitter Sustaining Voltage @ 100 mAdc VCEO(sus) = 60 Vdc (Min) - TIP120, TIP125
  - = 80 Vdc (Min) TIP121, TIP126 = 100 Vdc (Min) - TIP122, TIP127
- Low Collector-Emitter Saturation Voltage
  - V<sub>CE</sub>(sat) = 2.0 Vdc (Max) @ I<sub>C</sub> = 3.0 Adc = 4.0 Vdc (Max) @ I<sub>C</sub> = 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
- TO-220AB Compact Package
- TO-66 Leadform Also Available

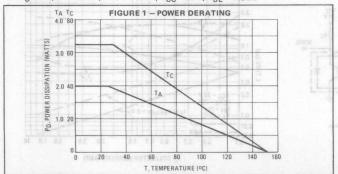
#### \*MAXIMUM RATINGS

MAXIMOM HATHING	1365/3				
Rating	Symbol	TIP120, TIP125	TIP121, TIP126	TIP122, TIP127	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	V <sub>CB</sub>	60	80	100	Vdc
Emitter-Base Voltage	VEB	4	5.0	-	Vdc
Collector Current — Continuous Peak	lc	4	— 5.0 — — 8.0 —	-	Adc
Base Current	1 <sub>B</sub>	4	120	-	mAdo
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	4	— 65 — — 0.52 —	=======================================	Watts W/OC
Total Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	PD	=	2.0 _ 0.016 _	1011-1	Watts W/OC
Unclamped Inductive Load Energy (1)	E	4	50	-	mJ
Operating and Storage Junction, Temperature Range	TJ, T <sub>stg</sub>	-	-65 to +150		°c

## THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit	
Thermal Resistance, Junction to Case	R <sub>θ</sub> JC	1.92	°C/W	
Thermal Resistance, Junction to Ambient	R <sub>θ</sub> JA	62.5	°C/W	

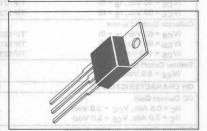
(1)  $I_C$  = 1 A, L = 100 mH, P.R.F. = 10 Hz,  $V_{CC}$  = 20 V,  $R_{BE}$  = 100  $\Omega$ .

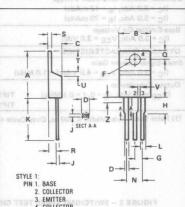


## DARLINGTON 8 AMPERE

## COMPLEMENTARY SILICON POWER TRANSISTORS

60-80-100 VOLTS **65 WATTS** 





	MILLIN	IETERS	INC	HES
MIC	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
В	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
0	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0 050
٧	1.14	-	0.045	3-12
Z	-	2.03	-	0.080

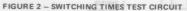
ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

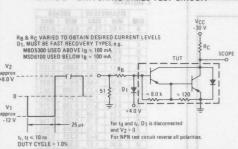
PLASTIC MEDIUM POWER

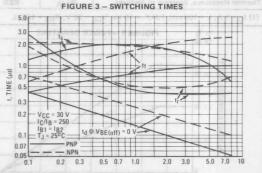


Characteristic				Symbol	Min	Max	Unit
OFF CHARACTERISTICS			Bumpan	Ms. Evapole, Ands. 13	the remaindance no	ortand inspiral	annitrations
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 100 mAdc, I <sub>B</sub> = 0)	TIP121,	TIP125 TIP126 TIP127		V <sub>CEO(sus)</sub>	60 80 100	0 (Typ) (@ lc	her = 250 ber = 250
Collector Cutoff Current (VCE = 30 Vdc, I <sub>B</sub> = 0) (VCE = 40 Vdc, I <sub>B</sub> = 0) (VCE = 50 Vdc, I <sub>B</sub> = 0)	TIP121	TIP125 TIP126 TIP127		ICEO	Min) = TIP121 Min) = TIP121 Min) = TIP122 ration Voltage	0.5	mAdc
Collector Cutoff Current (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)	TIP121,	, TIP125 , TIP126 , TIP127		ICBO ab	A 0.8 = 510 (x	0.2	abAmisor
Emitter Cutoff Current (VBE = 5.0 Vdc, IC = 0)				IEBO	- 6	2.0	mAdc mAdc
ON CHARACTERISTICS (1)					elds	have wele min	Aber 00 01 9
DC Current Gain (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 3.0 Vdc) (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc)		2(013	(10)22.	hFE	1000	850	MAXIMUR RATE
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 3.0 Adc, I <sub>B</sub> = 12 mAdc) (I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 20 mAdc)		55V	100	VCE(sat)	VGEQ- 60	2.0	Vdc
Base-Emitter On Voltage (I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc)		SBV	6	V <sub>BE</sub> (on)	- P -	2.5	militer-Backer Street
DYNAMIC CHARACTERISTICS		Jight	40	(2.9	D	No.	99
Small-Signal Current Gain (IC = 3.0 Adc, VCE = 4.0 Vdc, f = 1.0 MH)	z)	ob,Am Watts	9	Ihfel	4.0	2985 - 17 a	Bert Corrent out Power Diminatio
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)		, TIP126, , TIP121,	2	C <sub>ob</sub>	- » - o9	300	orat Power Dissipation Orate Books 2602

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.

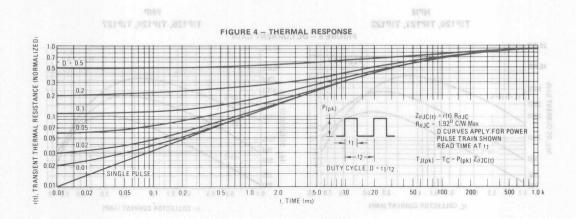




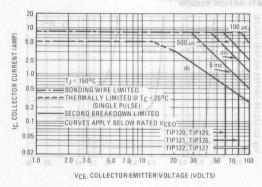


IC, COLLECTOR CURRENT (AMP)

## TIP120, TIP121, TIP122, NPN, TIP125, TIP126, TIP127, PNP 17 1917 1917

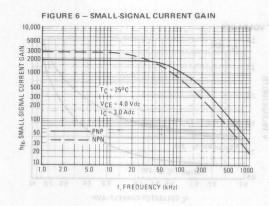


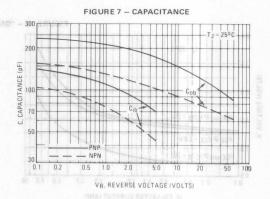
#### FIGURE 5 - ACTIVE-REGION SAFE OPERATING AREA

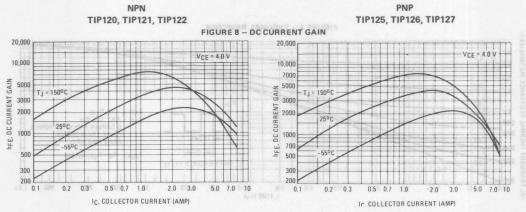


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C = V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on  $T_{J(pk)}$  =  $150^{\circ}$ C;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} < 150^{\circ}$ C.  $T_{J(pk)}$  may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown

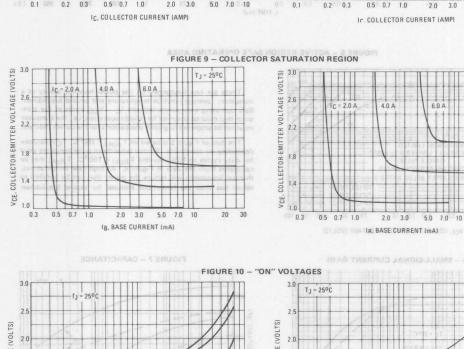


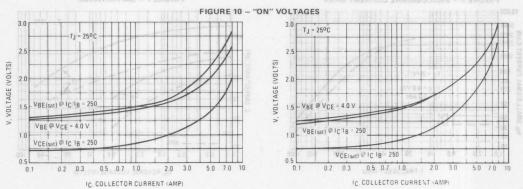




TJ = 25°C

20 30







## DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general-purpose amplifier and low frequency switching applications.

- High DC Current Gain Min hFE = 1000 @ IC = 5 A, VCE = 4 V
- Collector-Emitter Sustaining Voltage @ 30 mA

VCEO(sus) = 60 Vdc (Min) — TIP140, TIP145 80 Vdc (Min) - TIP141, TIP146 100 Vdc (Min) - TIP142, TIP147

Monolithic Construction with Built-In Base-Emitter Shunt Resistor

MAXIMUM	RATINGS	

MAXIMUM RATINGS					
Rating	Symbol	TIP140 TIP145	TIP141 TIP146	TIP142 TIP147	Unit
Collector-Emitter Voltage	VCEO	60	80	100	Vdc
Collector-Base Voltage	VCB	60	80	100	Vdc
Emitter-Base Voltage	VEB		5.0		Vdc
Collector Current — Continuous Peak (1)	Ic	10 15			Adc
Base Current — Continuous	IB	0.5			Adc
Total Device Dissipation @ T <sub>C</sub> = 25°C	PD	125		Watts	
Operating and Storage Junction	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150		°C	

## THERMAL CHARACTERISTICS

		4	
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}$ JC	1.0	°C/W
Thermal Resistance, Case to Ambient	R <sub>0.1A</sub>	35.7	°C/W

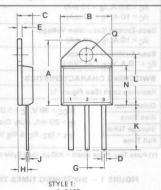
(1) 5 ms, ≤10% Duty Cycle | 7 21/4140 TIM2 - 9 3 HUDF

#### DARLINGTON SCHEMATICS NPN COLLECTOR PNP COLLECTOR **TIP140 TIP145 TIP141 TIP146** TIP142 **TIP147** BASEO BASE ≈8.0 k ≈40 ≈8.0 k ≈40 ~~~ **EMITTER EMITTER**

## 10 AMPERE DARLINGTON **COMPLEMENTARY SILICON** POWER TRANSISTORS

60-100 VOLTS 125 WATTS





- 1. BASE
- 2. COLLECTOR 3. EMITTER
- 4. COLLECTOR

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	2.41	3.20	0.095	0.126
J	0.38	0.64	0 015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	3.94	4.19	0.155	0.165

CASE 340-01 TO-218AC

TIP140, TIP145

TIP141 TIP146

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Garacteristic

OFF CHARACTERISTICS Collector-Emitter Sustaining Voltage (1)

(IC = 30 mA, IB = 0)

MOTOROLA

May



Unit

us

μS

μS

μS

TIP142, TIP147 100 Collector Cutoff Current mA CEO TIP140 TIP145 20 (V<sub>CE</sub> = 30 Vdc, I<sub>B</sub> = 0) THE -(VCE = 40 Vdc, IB = 0) TIP141, TIP146 2.0 (VCF = 50 Vdc, IB = 0) TIP142, TIP147 S oby 2.0 Collector Cutoff Current Ісво TIP140, TIP145 (VCB = 60 V, IE = 0) 1.0 TIP141 TIP146 (VCB = 80 V, IF = 0) 1.0 (V<sub>CB</sub> = 100 V, I<sub>F</sub> = 0) TIP142, TIP147 1.0 Emitter Cutoff Current VRF = 5.0 V 2.0 mA 1EBO ON CHARACTERISTICS (1) DC Current Gain hFE. (I<sub>C</sub> = 5.0 A, V<sub>CF</sub> = 4.0 V) 1000 (IC = 10 A, VCE = 4.0 V) 500 Collector-Emitter Saturation Voltage VCE(sat) Vdc  $(I_C = 5.0 \text{ A, I}_B = 10 \text{ mA})$ 2.0 (IC = 10 A, IB = 40 mA) 30 Base-Emitter Saturation Voltage VBE(sat) 3.5 Vdc (I<sub>C</sub> = 10 A, I<sub>B</sub> = 40 mA) Base-Emitter On Voltage 30 Vdc VBE(on) (IC = 10 A, VCE = 4.0 Vdc) SWITCHING CHARACTERISTICS Resistive Load (See Figure 1) Delay Time

Symbol

VCEO(sus)

td

tr

ts

tf

Min

60

80

## RB & RC VARIED TO OBTAIN DESIRED CURRENT LEVELS 01, MUST BE FAST RECOVERY TYPES, e.g., MBD5300 USED ABOVE IB ~ 100 mA MSD6100 USED BELOWIB ~ 100 mA V2 approx

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT

(VCC = 30 V, IC = 5.0 A,

(1) Pulse Test: Pulse Width = 300  $\mu$ s, Duty Cycle  $\leqslant 2.0\%$ 

I<sub>B</sub> = 20 mA, Duty Cycle ≤ 2.0%,

IB1 = IB2, RC & RB Varied, TJ = 25°C)

For NPN test circuit reverse diode and voltage polarities

For  $t_d$  and  $t_f$ , D1 is disconnected and  $V_2 = 0$ 

- 25 µs

t<sub>r</sub>, t<sub>f</sub> ≤ 10 ns DUTY CYCLE = 1.0%

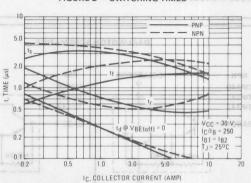
FIGURE 2 - SWITCHING TIMES

0.15

0.55

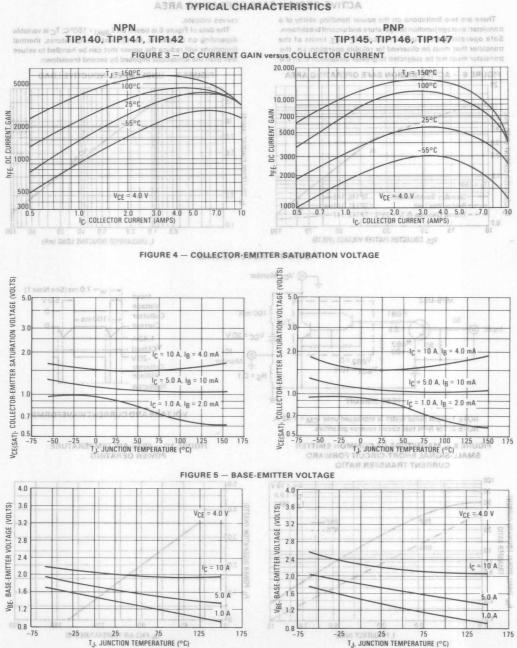
2.5

2.5



Rise Time

Storage Time



3-1287

TJ, JUNCTION TEMPERATURE (°C)

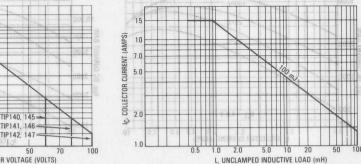
#### **ACTIVE-REGION SAFE OPERATING AREA**

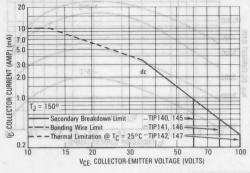
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate IC-VCF limits of the transistor that must be observed for reliable operation; i.e., the

transistor must not be subjected to greater dissipation than the

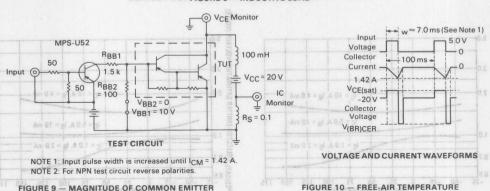
The data of Figure 6 is based on T<sub>J(nk)</sub> = 150°C; T<sub>C</sub> is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

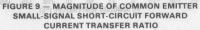


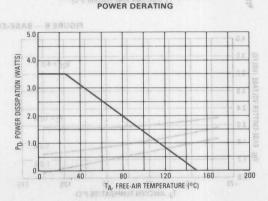


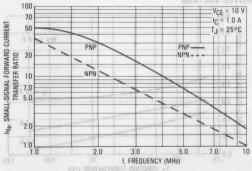


#### BOATLOV MONFIGURE 8 - INDUCTIVE LOAD - A BRUDH









#### COMPLEMENTARY SILICON POWER TRANSISTORS

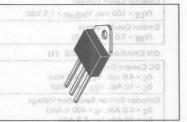
 $\ldots$  designed for general-purpose switching and amplifier applications.

- DC Current Gain hFE = 20-70 @ IC = 4.0 Adc
- Collector-Emitter Saturation Voltage V<sub>CE(sat)</sub> = 1.1 Vdc (Max)
   @ I<sub>C</sub> = 4.0 Adc
- Excellent Safe Operating Area

# ELECTRICAL CHARACTERISTICS IT

COMPLEMENTARY SILICON

90 WATTS

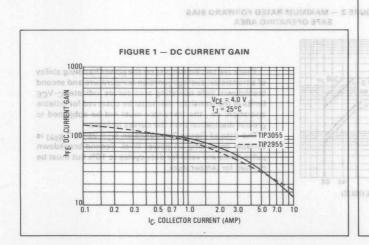


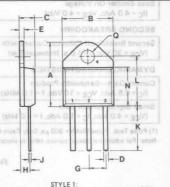
#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	60	Vdc
Collector-Emitter Voltage	VCER	70	Vdc
Collector-Base Voltage	VCB	100	Vdc
Emitter-Base Voltage	VEB	7.0	Vdc
Collector Current — Continuous	Ic	15	Adc
Base Current	IB	7.0	Adc
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> ,T <sub>stg</sub>	-65 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta}JC$	1.39	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	35.7	°C/W





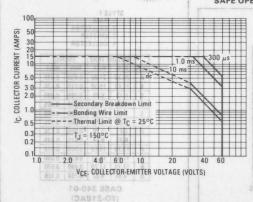
1.	BASE
2.	COLLECTOR
3.	EMITTER
4.	COLLECTOR

	MILLIN	MILLIMETERS		HES
DIM	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
В	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
Н	241	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

CASE 340-01 (TO-218AC)

BREGMA Characteristic	ORS	RST	Symb	ol	POY	Minosille	W Max	BA	CtinUPLE
OFF CHARACTERISTICS 3WO9									
Collector-Emitter Sustaining Voltage (1) (I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)	teillig	me	VCEO(s	us)	12 92	60	101190_101	138	Vdc
Collector Cutoff Current (VCE = 70 Vdc, RBE = 100 Ohms)			CER	4.0	ol @	= 20-70 (	33rd 1.0	E G	mAdc mAdc
Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)	(Max)	Velo	ICEO	VCE	- 501	ition V <del>ol</del> ta			-notomAde @
Collector Cutoff Current (VCE = 100 Vdc, VBE(off) = 1.5 Vdc)			ICEV			Area =	obsession	iafe	mAdc e
Emitter Cutoff Current (VBE = 7.0 Vdc, IC = 0)			IEBO			=	5.0		mAdc
ON CHARACTERISTICS (1)									
DC Current Gain (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc) (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)	tinU	0	hFE	lad	Sym	20 5.0	70	NG	RXIMUM RATI
Collector-Emitter Saturation Voltage (I <sub>C</sub> = 4.0 Adc, I <sub>B</sub> = 400 mAdc) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 3.3-Adc)	Vdc Vdc		VCE(sa	at) Oi	10V	+		raige raige	lector Emitter Vo
Base-Emitter On Voltage (I <sub>C</sub> = 4.0 Adc, V <sub>CE</sub> = 4.0 Vdc)	Vdc		V <sub>BE</sub> (o	n) g	gV		1.8		parlovVdc, a rettin
SECOND BREAKDOWN	ana.		7.0		ol of		CUNUIN		se Current
Second Breakdown Collector Current with Base F (V <sub>CE</sub> = 30 Vdc, t = 1.0 s; Nonrepetitive)	orward Biased		oe Is/b		q	3.0	@ Tc = 25°	no (	al Powork issipat
DYNAMIC CHARACTERISTICS		150	-65 to		TUT		unction		perating and Stora
Current Gain—Bandwidth Product (I <sub>C</sub> = 0.5 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)			fT			2.5	TERISTIC	e AC	empi SHMe Rang
Small-Signal Current Gain (V <sub>CE</sub> = 4.0 Vdc, I <sub>C</sub> = 1.0 Adc, f = 1.0 kHz)	ninU		hfe hfe	lod	Sym	15		_	sterio kHz

### FIGURE 2 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA



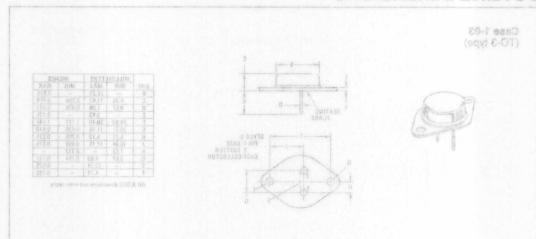
There are two limitations on the power handling ability of a transistor: average junction temperature and second

FIGURE 1 - DC CURRENT GAIN

breakdown. Safe operating area curves indicate I<sub>C</sub>-V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on T<sub>C</sub> = 25°C; T<sub>J</sub>(pk) is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature.

#### **OUTLINE DIMENSIONS**



#### MOUNTING HARDWARE — PIECE PARTS

Description	Part-Number
Case 346 Low Volt. Mica Insulator	B12387B001
Case 346 High Volt. Mica Insulator	B12387B002
Case 346 Screw	T15852A001
Case 353 Mica Insulator	B12387B003
Case 353 Screw	T15852A002
Case 77 Round Mica Insulator Case 77 Steel Washer	B52600F003 B52200F007
Case 90 Round Mica Insulator	B52600F013
Case 90 Steel Washer	B52200F004
TO220 Mica Insulator TO220 Nylon Bushing TO220 Steel Washer	T07743A001 T07872A001 B09002A001
TO3 SDT Mica Insulator TO3 High Volt. Mica Insulator TO3 High Volt. Big Mica Insulator TO3 Nylon Bushing	B52600F011 T05036A001 T05036A003 B51547F005
TO3P Mica Insulator	T10583A001
TO3P Nylon Bushing	T10582A001
TO66 Mica Insulator	B52600F008
TO66 Nylon Bushing	B51547F003

# Contents A0-1 eas0 AA0G-OT (90/8 E-OT)

Outline Dimensions Mounting Hardware **Page** 4-2 4-8

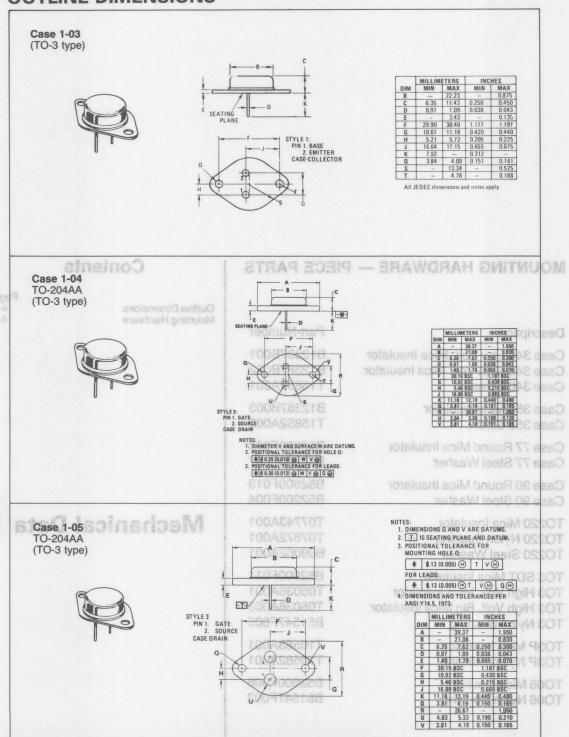


### **Mechanical Data**

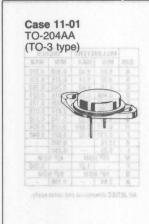
(TO-3 type)

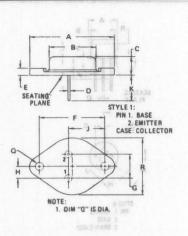


#### **OUTLINE DIMENSIONS**



#### OUTLINE DIMENSIONS (continued) SMOISMAMIC AMILTUO



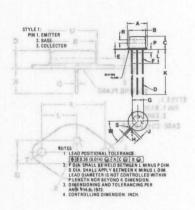


	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	1	39.37	_	1.550	
В	-	21.08	-	0.830	
C	6.35	7.62	0.250	0.300	
D	0.99	1.09	.0.039	0.043	
E	-	3.43		0.135	
F	29.90	30.40	1.177	1.197	
G	10.67	11.18	0.420	0.440	
H	5:33	5.59	0.210	0.220	
1	16.64	17.15	0.655	0.675	
K	11.18	12.19	0.440	0.480	
Q	3.84	4.09	0.151	0.161	
R	-	26.67	-	1.050	

Case 78-02

Case 31-03 (TO-5)



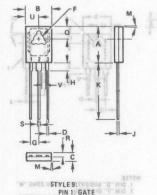




Case 80-02







	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.43
В	7.49	7.75	0.295	0.30
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.028
F	2.92	3.18	0.115	0.125
G	2.31	2.46	0.091	0.097
H.	1.27	2.41	0.050	0.095
J	0.38	0.64	0.015	0.025
K	15.11	16.64	0.595	0.65
M	16 3	O TYP	30 T	YP
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.05
S	0.64	0.89	0.025	0.03
U	3.68	3.94	0.145	0.15
V	1.02	-	0.040	37

Case 90-05

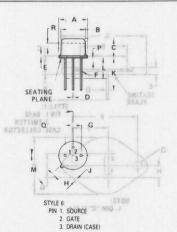
STYLE 9: PIN 1: GATE 2. DRAIN 3. SOURCE

Z MY2 2 GATE MT - MAIN TERMINAL

### OUTLINE DIMENSIONS (continued) SMOISMAMID BINLITUO







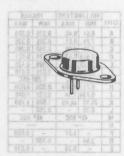
	MILLIM	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
В	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
Н	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	450 N	MOM	450 N	OM
P	-	1.27	-	0.050
Q	900 1	MON	90º N	MOI
R	2.54	-	0.100	-

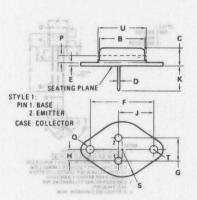
Case 11-01

All JEDEC dimensions and notes apply.

Case 31-03

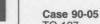
Case 80-02 TO-66





	MILLI	METERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
B	11.94	12.70	0.470	0.500	
C	6.35	8.64	0.250	0.340	
D	0.71	0.86	0.028	0.034	
E	1.27	1.91	0.050	0.075	
F	24.33	74.43	0.958	0.962	
G	4.83	5.33	0.190	0.210	
Н	2.41	2.67	0.095	0.105	
J	14.48	14.99	0.570	0.590	
K	9.14	-11/	0.360	-	
P	76	1.27	-	0.050	
Q	3.61	3.86	0.142	0.152	
S	- /	8.89	-	0.350	
T	-110	3.68	-	0.145	
U	15-11	15.75	-	0.620	

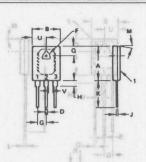
All JEDEC Dimensions and and Notes Apply.





STYLE 1: PIN 1. CATHODE 2. ANODE 3. GATE STYLE 4:

PIN 1, MT1 2. MT2 3. GATE MT - MAIN TERMINAL

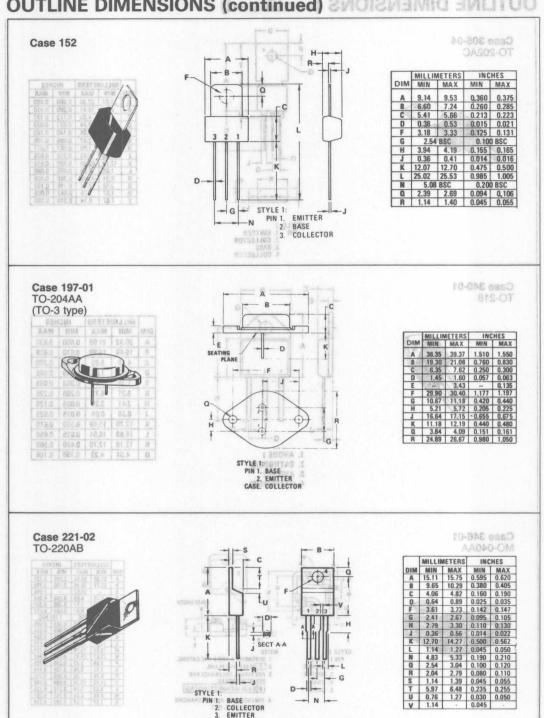


NOTES:
1. DIM "D" UNCONTROLLED IN ZONE "M"
2. DIM "F" DIA THRU
3. HEAT SINK CONTACT AREA (BOTTOM)
4. LEADS WITHIN 8.000" RAD OF TRUE
POSITION (TP) AT MAXIMUM MATERIAL CONDITION.

### Case 77-04

	MILLIN	IETERS	1100	CHES
DIM	BALIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0 645
8.0	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
0	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.2	BSC	0.16	6 BSC
H	2.67	2.92	0.105	0.115
1	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	90 TYP 90		90	TYP
0	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255
٧	2.03	-	0.080	-

### OUTLINE DIMENSIONS (continued) SMOISMAMIG AMILITUO

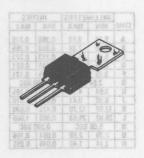


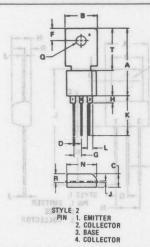
STYLE 1:

PIN 1. BASE 2. COLLECTOR 3. EMITTER

### OUTLINE DIMENSIONS (continued) SMOISMEMED EMILITUO

Case 306-04 TO-202AC

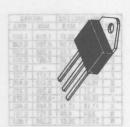


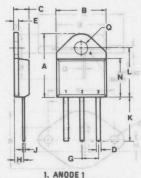


93	MILLIN	ETERS	INC	HES
DIM	MIN	MAX	MIN	MAX
A	21.84	22.35	0.860	0.880
B	9.91	10.41	0.390	0.410
C	4.39	4.65	0.173	0.183
D	0.58	0.74	0.023	0.029
E	3.56	4.06	0.140	0.160
G	2.41	2.67	0.095	0.105
H	1.70	1.96	0.067	0.077
J	0.48	0.66	.0.019	0.026
K	12.19	12,95	0.480	0.510
L	1,65	2.03	0.065	0.080
N	9.91	10.16	0.390	0.400
0	3.56	3.81	0.140	0.150
R	1.07	1.75	0.042	0.069
T	7.87	9.14	0.310	0.360

Case 152

Case 340-01 TO-218



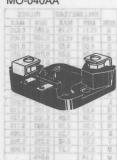


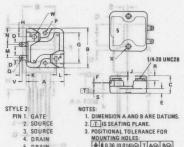
- 2. CATHODE(S) 3. ANODE 2 4. CATHODE(S)
- DIM MIN MAX MIN MAX A 20.32 21 08 0.800 0.830 B 15.49 15.90 0.610 0.626 C 4.19 5.08 0.165 0.200 D 1.02 1.65 0.040 0.065 E 1.35 1.65 0.053 0.065 G 5.21 5.72 0.205 0.225 H 2.41 3.20 0.095 0.126 J 0.38 0.64 0.015 0.025 K 12.70 | 15.49 | 0.500 | 0.610 15.88 16.51 0.625 0.650 N 12.19 12.70 0.480 0.500 Q 4.04 4.22 0.159 0.166

INCHES

MILLIMETERS

Case 346-01 MO-040AA



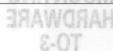


- 1. DIMENSION A AND B ARE DATUMS.
  2. T IS SEATING PLANE.
  3. POSITIONAL TOLERANCE FOR
  - 4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIN	ETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
A	53.09	53.84	2.090	2.120	
В	55.37	56.39	2.180	2.220	
C	-	26.67	-	1.050	
D	6.10	6.60	0.240	0.260	
E	6.60	7.11	0.260	0.280	
F	0.71	0.81	0.028	0.032	
G	43.31 BSC		1.705 BSC		
H	12.57	12.82	0.495	0.505	
J	1.52	1.62	0.060	0.064	
K	9.50	9.75	0.374	0.384	
L	10.21	10.46	0.402	0.412	
M	18.92	19.18	0.745	0.755	
N	23.67	23.93	0.932	0.942	
P	5.08	5.21	0.200	0.205	
0	3.53	3.78	0.139	0.149	
R	6.76	7.26	0.266	0.286	
S	14.73	15.24	0.580	0.600	
٧	5.33	5.84	0.210	0.230	
W	6.40	6.65	0.252	0.262	
X	7.37	7.87	0.290	0.310	

Case 221-02 TO-220AB

5. DRAIN



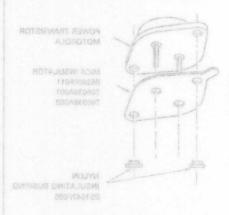
	MILLI	WETERS	INCHES		
MIC	MODE	MAX	MIN	MAX	
A	39.11	40.13	1.540	1.580	
В	33.93	34.95	1.336	1.376	
3	-	20.32	-	0.800	
D	0.68	0.83	0.027	0.033	
E	8.30	8.81	0.327	0.347	
F	-	4.44	-	0.175	
G	29.67 BSC		1.168 BSC		
Н	5.08 BSC		0.200 BSC		
J	0.93	1.09	0.037	0.043	
K	-	25.40	-	1.000	
L	2.92	3.30	0.115	0.130	
N	17.14	17.39	0.675	0.685	
0	3.73	3.88	0.147	0.153	
R	10.41	10.79	0.410	0.425	
S	5.84	6.35	0.230	0.250	
U	M5	.8 (MET	RIC TH	RD)	
٧	1.27	1.52	0.050	0.060	
W	4.69	4.85	0.185	0.191	
X	30.1	5 BSC	1.18	BSC	

Case 353-01	
	STME 2:
	PIN 1. GATE 2. SOURCE 3. URAIN 4. DRAIN
This hardware is applicable to the following packages.	-T-V

3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1982.
4. CONTROLLING DIMENSION: INCH EXCEPT FOR METRICALLY THREADED INSERTS.
5. MOUNTING HOLE CENTERS (DIMENSION X) SAME AS TO-204 (TO-3) FAMILY.



CASE 1 (TO-8) CASE 11A CASE 54



\* Longer screws (not available from Motorola) and multiple bushings may be required for thick chassis or freat sink.



MOTOROLA

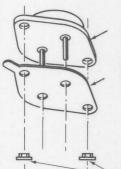


This hardware is applicable to the following packages.

2. DIMERDOWING AND TOLERANDING FER AND YEES, 1962. CASTROLING DIMERDIGH, BIDDH EXCEPT FOR MITTRIDALLY THIREADED DIGERTIAL COUNTING NO. CASTROLING TOLERAND ALGORIES.

BRITHUGH ROT BORAFING

HOLES (8.2) (8.0) (1 A.C.) (9.0)

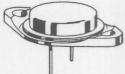


POWER TRANSISTOR MOTOROLA

MICA INSULATOR B52600F011 T05036A001 T05036A003

NYLON INSULATING BUSHING B51547F005





**CASE 1** (TO-3) CASE 3 CASE 11A **CASE 11** (TO-3) CASE 12 CASE 54 CASE 197 (except T05036A001)

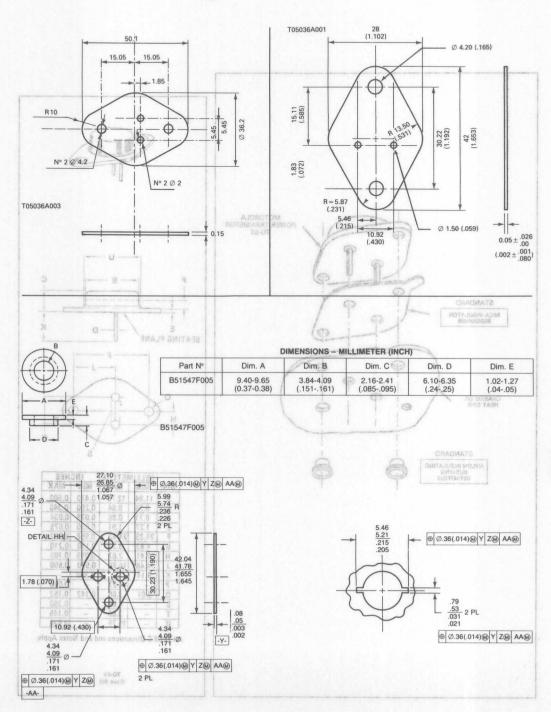
<sup>\*</sup> Longer screws (not available from Motorola) and multiple bushings may be required for thick chassis or heat sink.

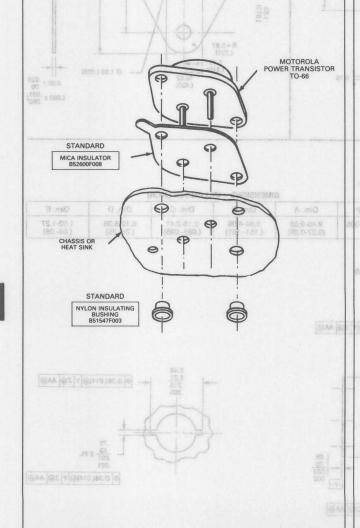


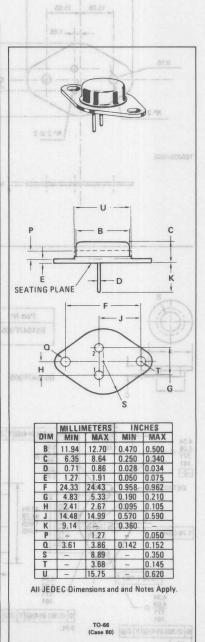
#### **MOUNTING HARDWARE TO-3**



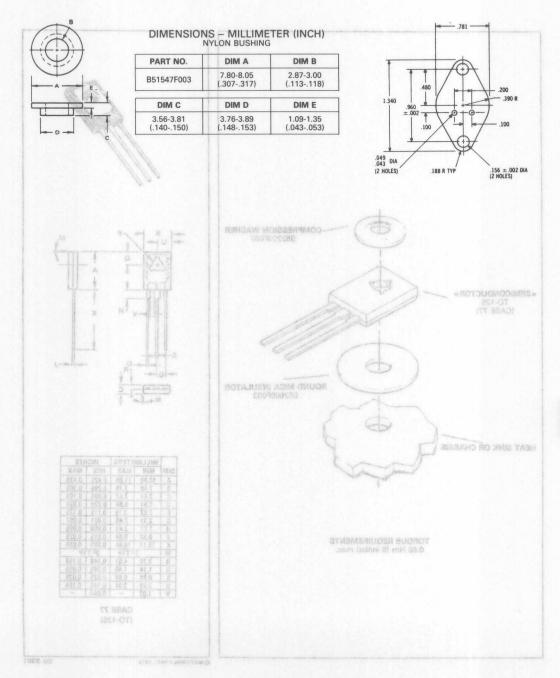
# MOUNTING HARDWARE TO-66





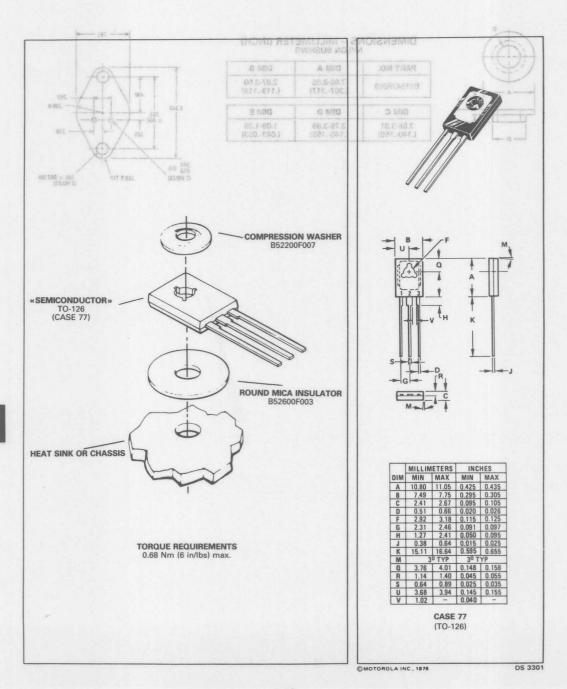






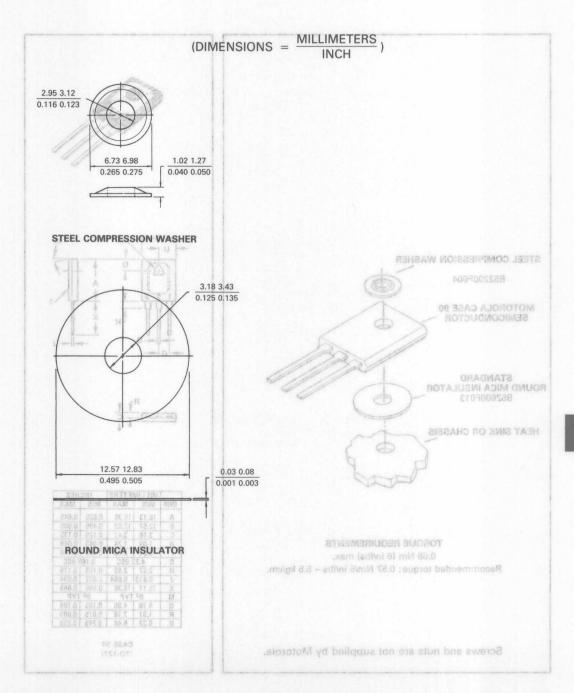
### MOUNTING HARDWARE TO-126



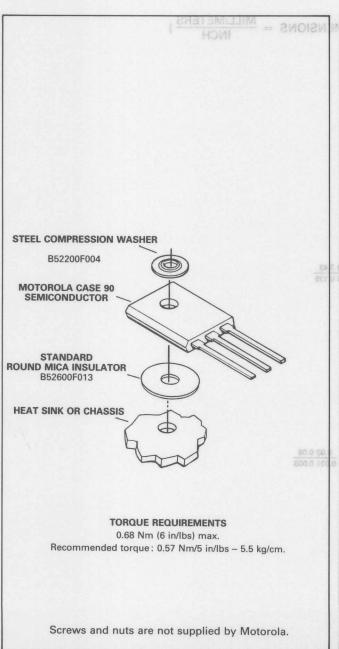


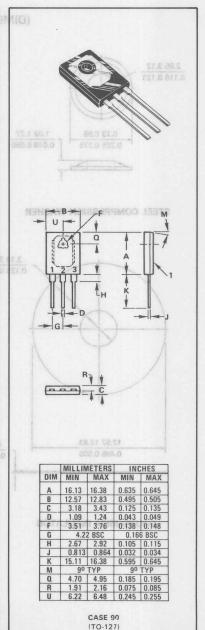
#### **MOUNTING HARDWARE TO-126**







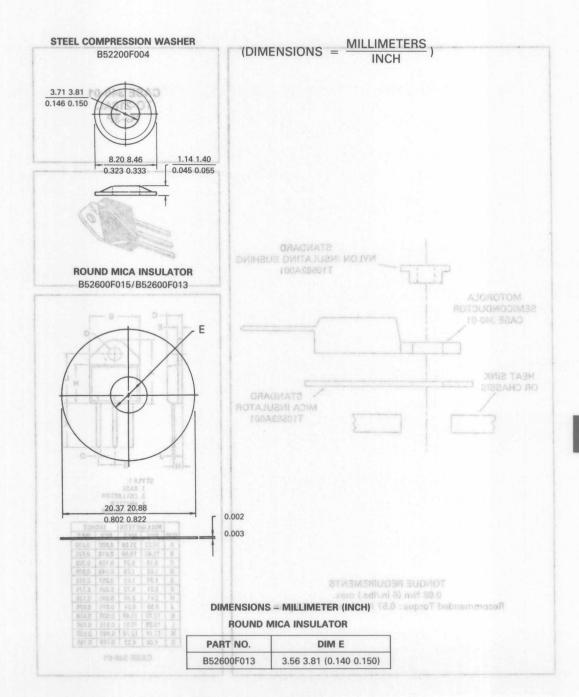




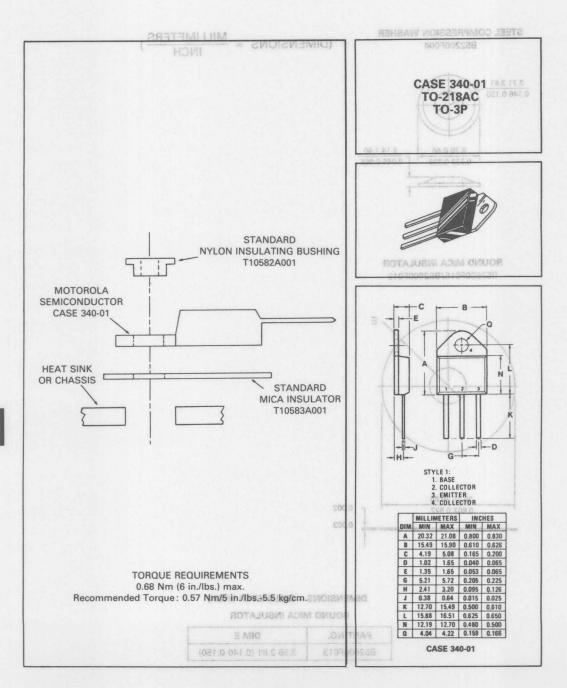
#### **MOUNTING HARDWARE TO-127 (CASE 90)**



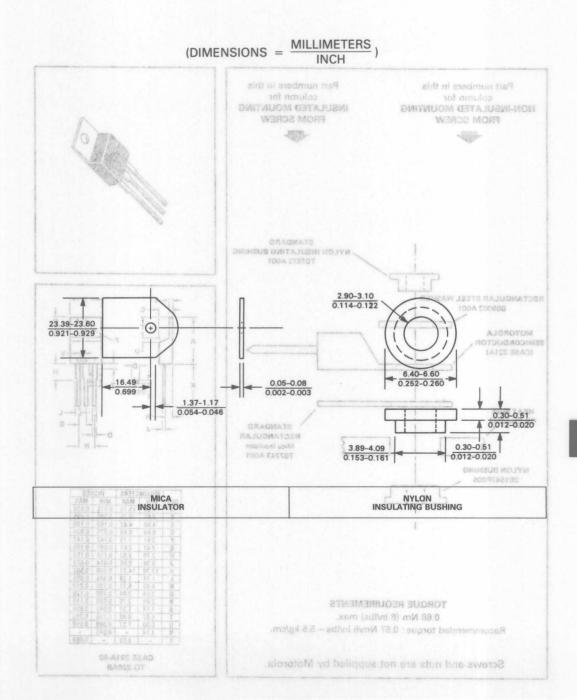
MOUNTING HARDWARE TO-218AC TO-3P





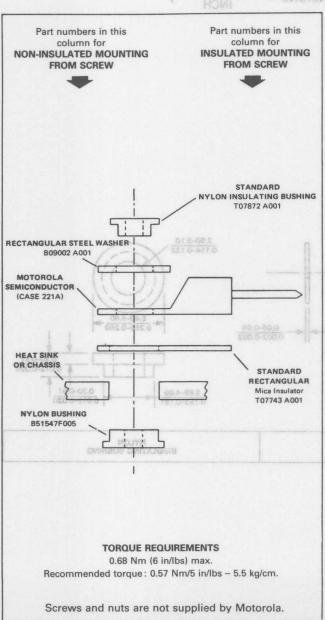


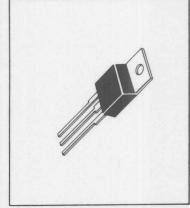
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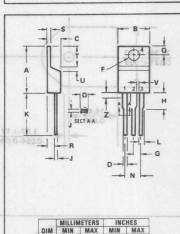


T

IENSIONS = MILLIMETERS)







DIM	MILLIM	ETERS	INCHES		
	MIN	MAX	MIN	MAX	
A	14.60	15.75	0.575	0.620	
В	9.65	10.29	0.380	0.405	
C	4.06	4.82	0.160	0.190	
D	0.64	0.89	0.025	0.035	
F	3.61	3.73	0.142	0.147	
G	2.41	2.67	0.095	0.105	
Н	2.79	3.93	0.110	0.155	
J	0.36	0.56	0.014	0.022	
K	12.70	14.27	0.500	0.562	
L	1.14	1.39	0.045	0.055	
N	4.83	5.33	0.190	0.210	
0	2.54	3.04	0.100	0.120	
R	2.04	2.79	0.080	0.110	
S	1.14	1.39	0.045	0.055	
T	5.97	6.48	0.235	0.255	
U	0.00	1.27	0.000	0.050	
٧	1.14	-	0.045	-	
Z	-	2.03	-	0.080	

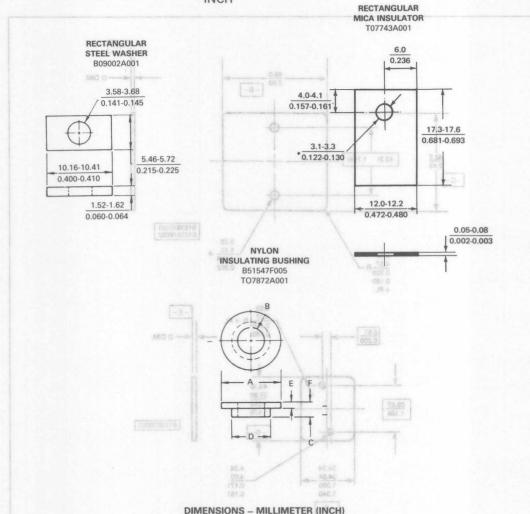
TO-220AB

#### **MOUNTING HARDWARE TO-220AB**



MOUNTING HARDWARE CASE 346-01 CASE 353-01

(DIMENSIONS =  $\frac{\text{MILLIMETERS}}{\text{INCH}}$ )

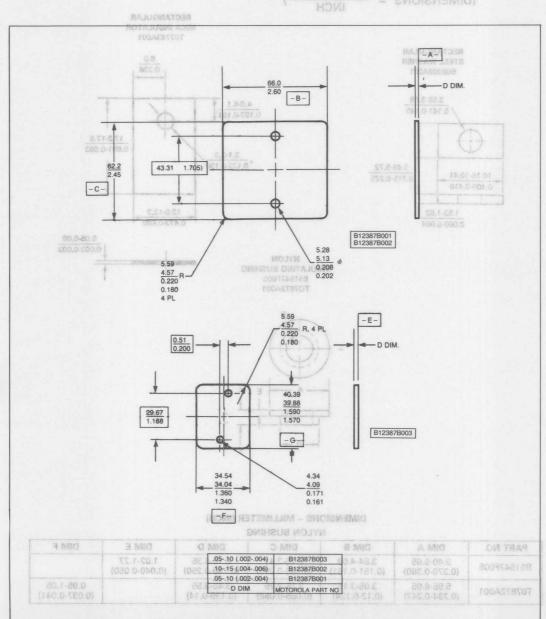


#### DIMENSIONS – MILLIMETER (INCH) NYLON BUSHING

PART NO.	DIM A	DIM B	DIM C	DIM D	DIM E	DIM F
B51547F005	9.40-9.65 (0.370-0.380)	3.84-4.09 (0.151-0.161)	2.16-2.41 (0.085-0.095)	6.10-6.35 (0.240-0.250)	1.02-1.27 (0.040-0.050)	
T07872A001	5.95-6.05 (0.234-0.247)	3.05-3.15 (0.12-0.124)	2.15-2.25 (0.085-0.088)	3.45-3.55 (0.136-0.14)		0.95-1.05 (0.037-0.041)



 $(DIMENSIONS = \frac{MILLIMETERS}{INCH})$ 



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### Application Notes

#### POWER SUPPLY CIRCUIT DESIGN

#### AN-719 A New Approach to Switching Regulators

This article describes a 24-Volt. 3-Ampere switching mode supply. It operates at 20 kHz from a 120 Vac line with an overall efficiency of 70%. New techniques are used to shape the load line. The control portion uses a quad comparator and pote coupler and features short circuit and restriction.

### AN-725 A Low-Cost 80 V-1.5 A Color TV Power Supply

A full-wave SCR power supply is proposed for application in line operated color television receivers. Economy of design is maintained while providing good regulation against line, load and temperature changes.

#### AN-737A Switched Mode Power Supplies—Highlighting a 5-V, 40-A Inverter Design

This application note identifies the features of various regulator circuits that are in use today in AC to DC power supplies. The note also lifustrates how these circuits may be used as complementary building blocks in a system design. Primary emphasis is on swiftched mode regulators beause they till the present need for energy and space savings.

A complete 5-V, 40-A line operated inverter supply is described in detail including design procedures for the magnetic components. The inverter itself is a "state-of-the-art" design which features CMOS logic, high voltage power trensistors. Schottky rectifiers and an opto-electionic coupler, it operates with a full load efficiency of

#### Page

#### AN-752 An 80-Watt Switching Regula for CATV and Industrial Applications

This application note describes a 24-Vol Ampere switching, regulated power supply operates above 18 kHz from a 40-to 60-Volt Hz square wave source (CATV power line-fro ferroresonant fransformar) or a dc star

### **Application Notes**

and a linear integrated circuit timer which are used to vary the on time of a new high-steed power transistor. The circuit provides good efficiency, good regulation, low output hipple and incorporates input and output voltage over shutdown protection.

### AN-767 A Line Operated, Regulated 5V/50A Switching Power Supply

This application note describes a regulated 220V ac to 5 Vdc converter using high voltage switching transistors and Schottky barrier rectifiers. The control functions are all performed by integrated circuits.

#### AN-786 Power Darlington Load Line Considerations

Power Darlington load lines are discussed in the light of a typical application of a Switchmode Darlington power transistor. Darlington advantages are reviewed and the test circuit is introduced. Load line analysis revealed a reverse bias SOA problem and just enough snubbing was used to insure reliability without unduly sacrificing efficiency.

#### AN-803 The Effect of Emitter-Base Avalancing on High-Voltage Power Switching Transistors

Reverse biasing the base of a power transistor during turn-off decreases its turn-off switching losses. This application note investigates the effect of increasing the bias into avalanche on the life, switching speeds and inductive turn-off stresses on several types of high-voltage switching power transistors.

### AN-828 The Effects of Base Orive Con-

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Circuit Design 5-2
Audio Control
Circuit Design 5-3
Power Transistor 5-4

Power MOSE-ETS are recognized as being extremely fast switching devices, but are they more efficient than bipolars in all or many high voltage switching applications? The answer is—it depends. Efficiency is a measure of dissipation, which, in switchmode circuits, consists primarily of switching losses, both turn-off and turn-on, and saturation losses. Since switching frequency losses are a function of the switching frequency and saturation losses are relatively constant, there reaches a point in the frequency spectrum.

### **Application Notes**

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5

where one loss predominates over the other. Thus, in low frequency applications, devices with low saturation or ON voltage would show lower losses as measured by the device case temperature and at high frequencies, the fast switchers would run cooler.

#### AN-861 Power Transistor Safe Operating Area—Special Considerations for Motor Drives

Motor drives present a unique set of safe operating area conditions to power output transistors. Starting with the basics of forward and reverse safe operating area, considerations unique to motor drives are discussed.

### EB-66A A Symmetry Correcting Circuit for Use with the MC3420

EB-66 shows a method of implementing an external symmetry-correction circuit with the MC3420 Switchmode Regulator Control IC to

AN-873 Understanding Power Transistor Dynamic Behavior-dv/dt Effects on

readily shows how these limitations arise. A sim-

Switching RBSOA-

where one loss predominates over the other. Insure balanced operation of the power transformer in push-pull inverter configurations.

### MC3420/3520 Switchmode Regulator

The MC3520/3420 is an inverter control unit which provides all the control circuitry for PWM push-pull, bridge and series type Switchmode power supplies.

### TL494/495 Switchmode Pulse Width Modulation Control Circuits

The TL494 and TL495 combine the best features of existing PWM control circuits and add other on-chip functions. These devices provide, on a single monolithic chip, all the control circuitry for PWM push-pull, bridge and series type switchmode power supplies.

uation methods for the thermal system.

AN-785 Reverse Bias Safe Operating

#### bestmill boyd of a costage AUDIO CONTROL CIRCUIT DESIGN 199019 Studes of sizylans

### AN-240 SCR Power Control Fundamentals

Relationships of control angle to peak voltage, average voltage, RMS voltage and power are presented in chart form. Time constants for relaxation oscillators are discussed for both DC and AC supplies. These basic form the heart of SCR control.

## AN-483B 20 and 30 Watt Power Application State of the Amplifiers Using Darlington Output Transistors

Use of monolithic power Darlington output transistors can greatly simplify the design of highfidelity amplifiers. Described herein is a 20-Watt amplifier which uses only three transistors, and a 30-Watt amplifier which uses four.

#### AN-484A Medium-Power Audio Amplifiers

This note describes a basic circuit design approach for audio complementary power amplifiers. Procedures are detailed for the selection of input, driver and output transistors. Both simple and Darlington transistor systems are included. Biasing, thermal considerations, overload protection and power supply information is given extensive treatment.

Design examples, including all circuit values, performance data and and suggested P.C. board layouts, are given for simple transsistor amplfiers at the 3, 5, 7, 10, 15, 20, 25, and 35 Watt

levels. Also included are three amplfiers using Darlington output transistors at the 15, 20, and 25 Watt levels.

examined. Clamped inductive turn-off measure-

### AN-485 High-Power Audio Amplifiers with Short-Circuit Protection Appendix

mended circuit approach for high-performance audio amplifiers in the 35-Watt to 100-Watt RMS power range. Circuitry is included which enables the amplifier to operate safely continuously under any load condition including a short.

### AN-755 Solid-State Relays for AC Power A Control

Solid-State Relays (SSRs) using both SCRs and Triacs are examined in detail. The advantages and disadvantages of SSRs compared with electromechanical relays are discussed. Inductive loads are reviewed and snubbing suggestions made. Parts lists are given for SSRs for voltages of 120 and 240 V rms and currents from 5 to 113 A rms. Also described are circuits to give ac and CMOS compatibility.

### AN-766 A Variable Frequency Control for 3Ø Induction Motors

This application note describes a variable variable voltage drive system for three-phase induction motor controls. A survey of possible system configurations and a detailed description of a semi-converter/transistor inverter quasisquare wave drive system are included.

### AN-569 Transient Thermal Resistance — General Data and Its Use

former in push-pull inverter configurations.

Data illustrating the thermal response of a number of semiconductor die and package combinations are given. Its use, employing the concepts of transient thermal resistance and superposition, permit the circuit designer to predict semiconductor junction temperature at any point in time during application of a complex power pulse train.

### AN-778 Mounting Techniques for Power Semiconductors Sent another and Analysis and Another Sent Another Another Sent Another Another Sent Another Anoth

For reliable operation, semiconductors must be properly mounted. Discussed are aspects of preparing the mounting surface, using thermal compounds, insulation techniques, fastening techniques, handling of leads and pins, and evaluation methods for the thermal system.

### AN-785 Reverse Bias Safe Operating Area

The rating of high voltage, high speed switching transistors for safe turn-off operations is examined. Clamped inductive turn-off measurements are used to generate a switching RBSOA—reverse bias safe operating area—which can be used in conjunction with load line analysis to assure proper transistor operation. The effects of inductance, temperature, base turn-off conditions and forward base drive on RBSOA are included in the discussion.

#### EN-101 Verifying Collector Voltage Haw 32 Ratings Ham A of the American American

Methods of verifying the various voltage ratings given on transistor data sheets are described. Practical test circuits are given and testing problems are discussed. A detailed discussion of the avalanche breakdown mechanism and the significance of various voltage ratings is also included.

### AN-828 The Effects of Base Drive Conditions on RBSOA

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#### AN-845 New Power Bipolars Compare Favorably with FETs for Switching Efficiency

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This application note discusses whether Power MOSFETs are more efficient than Bipolars in all or many high voltage switching applications.

#### AN-873 Understanding Power Transistor Dynamic Behavior—dv/dt Effects on Switching RBSOA—

MC3420 Switchmode Regulator Control IC to

Power transistor dynamic behavior can be affected to a large extent by dv/dt limitations. A look at the internal workings of the transistor readily shows how these limitations arise. A simple circuit model is developed which reproduces the behavior of power transistors in dv/dt limited modes of operation. Experience with the model gives some guidelines for minimizing dv/dt limitations in practical circuits.

# AN-875 Power Transistor Safe Operating Area—Special Considerations for Switching Power Supplies

age, average voltage, RMS voltage and power

Relationships of control angle to peak volt-

The purpose of this application note is to take a look at some of the more subtle aspects of how stress imposed by the power supply relates to transistor safe operating area and differentiate those stresses that the transistor can handle from those it cannot. In order to provide a proper foundation, special considerations are proceeded with a review of forward bias safe operating area.

AN-484A Medium-Power Audio Amplifiers

and a 30-Watt amplifier which uses four

This note describes a basic circuit design approach for audio complementary power amplifiers. Procedures are detailed for the selection of input, driver and output transistors. Both simple and Darlington transistor systems are included. Biasing, thermal considerations, overload protection and power supply information is given relative treatment.

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